Forest Ecosystem Study Unit

for the

Georgia Envirothon

Prepared by the
Chattahoochee-Oconee National Forests
with assistance from
Georgia Forestry Commission

Forest Ecosystems

Overview

Georgia has a great diversity of forest ecosystems. Much of this is due to the variation in climate, elevation, soil types and water within the state. Human use of the land is also a big factor influencing the ecosystems existing here. Urban ecosystems, with their great expanse of paved areas, influence water runoff, heat absorption, vegetation present, etc. If humans did not build cities, farm, fertilize, irrigate, use herbicides, burn, mow or otherwise alter the natural environment, then natural regeneration would produce forest ecosystems on the land.

Georgia has 14 congressionally designated wildernesses where nature is allowed to take its course with little or no influence from people. These areas not only preserve the wild character of the land, but offer an outdoor laboratory to study natural changes on the land. Most of these wildernesses are located on the Chattahoochee National Forest in north Georgia. In addition, Georgia has over 800,000 acres of national forests and nearly 24 million acres of productive forestland. Most of the commercial forests are located in middle and south Georgia. These forests have used the multiple-use sustained-yield management model for years but are following the lead of public forest lands away from the sustained-yield of timber to sustaining forest health, biological diversity, ecological processes, and other values including aesthetics. This ecosystem based approach implies a new level of cooperation by various land owners who may all have different management objectives, and who collectively seek many uses from the forests.

Balancing the conservation and development of natural resources is a tremendous task. It begins with an understanding of just what is an ecosystem, how it functions and changes.

Ecosystem Structure

Objectives

1. Define an ecosystem.
2. Identify living and nonliving components of an ecosystem.
3. Know the hierarchial structure for describing ecosystem scale.
4. Distinguish between physiographic region and ecological regions.
5. Categorize different types of forests.
6. Understand the functions of forests.
7. Identify products that come from trees.

What is an ecosystem?

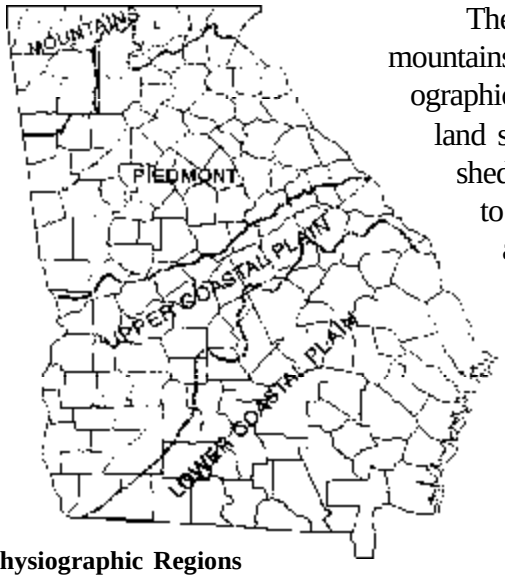
An ecosystem is a community of living and nonliving components functioning as an interdependent unit. Examples of ecosystems are wetland, prairie, desert, tropical rain forest, coniferous forest, hardwood forest, etc. Ecosystems vary in size, scale, diversity and connections.

All materials in an ecosystem cycle and change over time. Some changes occur as a result of natural cycles such as the carbon and water cycles, or as a result of natural disasters, human migration, urbanization, industrialization, war and other interactions with the environment. Changes that occur over long periods of time such as species adaptation, continental drift, or global warming are difficult to perceive. Ecosystems are connected at various scales and many of the connections are complex and difficult to understand. For example, scientists have observed a thinning of the ozone layer but do not yet have a full understanding of all the contributing causes or the effect it will have on earth's ecosystems.

The living and nonliving components of ecosystems can be classified into three general categories. These are the *producers, consumers* and *decomposers*. The number, diversity and balance of these components are indicators of ecosystem health. The challenge is to sustain ecosystems so that they will continue to provide human, and ecological needs for this and future generations.

Ecosystem Classification

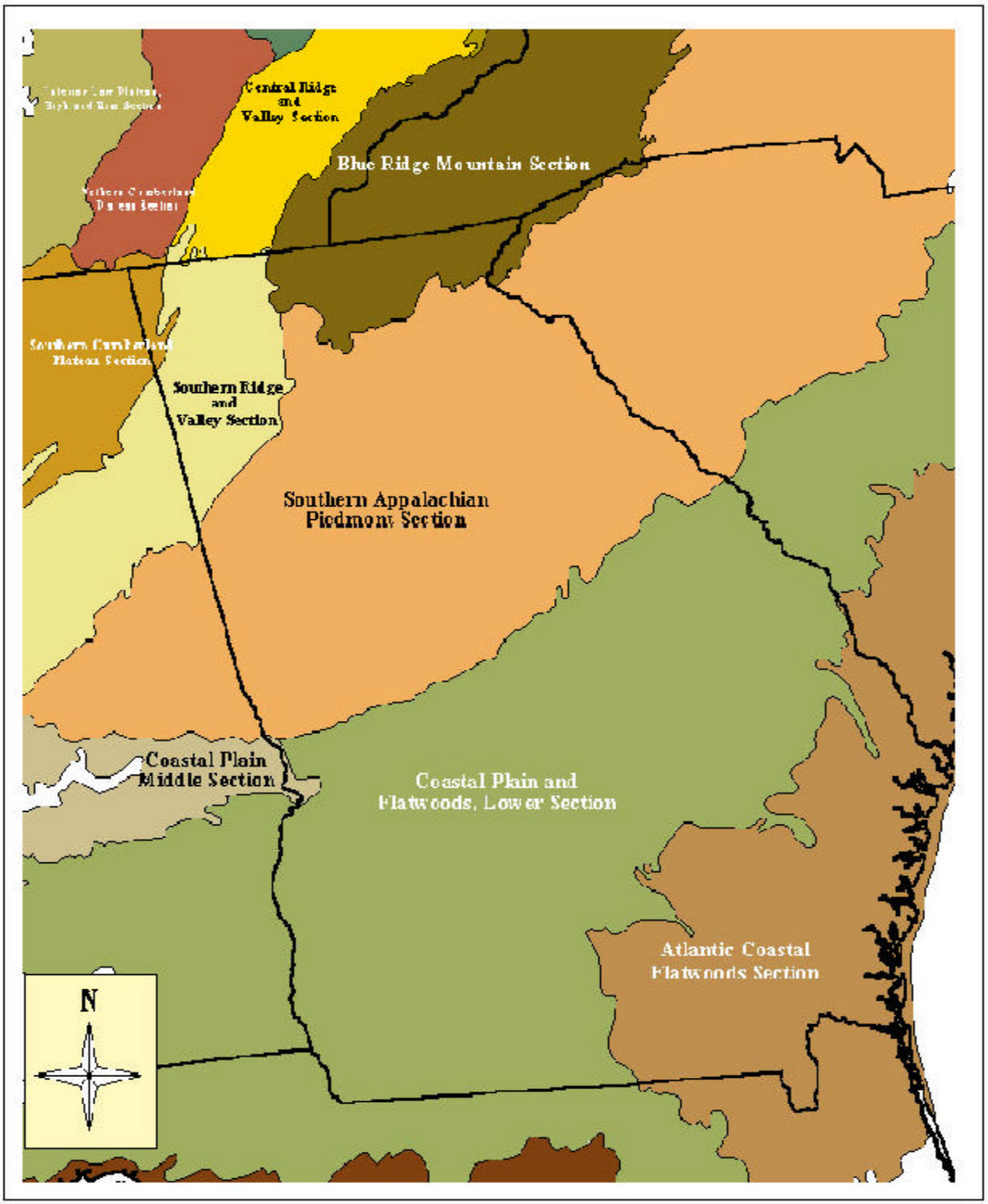
The hierarchial structure for broadly describing the scale of ecosystems is *domain, division, province* and *section*. The subdivision goes much smaller to allow for specific variations. The classifications are based on observed properties and existing knowledge. The main factors are climate, forest types or vegetation, soil types and water. The boundaries between adjacent ecosystems are usually difficult to locate precisely as one region gradually merges into another.



Physiographic Regions

The broad physiographic regions of Georgia include the mountains, piedmont, upper and lower coastal plains. Physiographic regions are determined by the physical features on the land such as soil types, rocks, minerals, elevation and watersheds. Ecological regions add climate and vegetation types to the picture. Physiographic and ecological regions, can and do change over time as evidenced by geological records. Refer to the satellite map, "Forest Type Groups of the United States", included with this study unit. The forest cover shown for Georgia, closely follows the physiographic regions and the ecological sections. From this map, you can see Georgia has the greatest diversity of forest types in the eastern United States.

Ecological Classification System
Sections in Georgia



Forest Ecosystems

Dictionaries define a forest as a large area densely covered with trees. Trees are the largest plants on earth and are producers of food and oxygen in the forest ecosystem. Forests are among the most valuable of the natural resources both for the products they provide and for the intricately woven community of life they host. The community of life includes animals as well as plants that range in size from microorganisms to great oaks and mighty sequoias.

Forests are renewable resources. That is, they will grow back. Nonrenewable natural resources such as oil and minerals will not be replaced by natural processes within a reasonable amount of time. The way humans use the forest greatly impacts its resilience. Each component of the forest community plays a role in continuing the cycle of life, death and rebirth. Some insects pollinate trees while others destroy them by eating leaves and wood. Squirrels eat tons of nuts, but bury others that germinate and survive to become mature trees. Some fungi infect living trees and kill them, while others break down dead plant and animal material releasing nutrients to nurture new generations of living things. Deer, bears, birds, beetles, butterflies and many other creatures live in the forest and contribute to its web of life. This intricate web is the forest ecosystem.

The traditional definition of forestry is the science of planting, growing and harvesting trees. Today the production of wood fiber is not the only objective. Forestry is coming to mean practicing the science in such a manner that the communities of life in a forest will be sustained. This is called ecosystem management.

What are the different kinds of forests?

Broad zones of different types of forests cover much of the earth. Climate, elevation and soil type are the primary factors which determine the climax forest type in an area. The major forest-type zones are:

Coniferous forests or cone-bearing trees with needlelike leaves which do not shed in winter. They are predominate in the colder northern latitudes and portions of the coastal plains but scattered pockets are found throughout the southern United States. Conifers can survive on poorer soil than broadleaf trees. Conifers are generally referred to as softwoods. The wood is valuable for lumber, certain musical instruments, paper, and for resins.

Deciduous forests are the broadleaf trees noted for their brilliant color change in autumn just before the leaves fall. They once covered vast areas of the temperate zone but most were cut down as human populations grew. Most broadleaf trees are considered hardwoods and include oaks, hickories, maples, sweet gum, yellow poplars and many other species. They are valuable for fine furniture, lumber, fruits, nuts and saps.

Mixed forests grow where conifers can compete on a more or less equal basis with broad-leaf trees. They form a transitional zone between coniferous and deciduous forests and contain species of both forest types.

Tropical rainforests flourish in the tropics where humidity is high and where there is heavy rainfall almost daily. Temperatures are warm with little seasonal variance. Diversity is greatest in the tropical rainforests. Thousands of species of trees thrive here. These forests contribute to the stability of the earth's climate.

Mountain forests may have lush tropical evergreens or wind-twisted conifers depending on the location and climate. Most of these forests are in Alaska, Canada, the Rocky Mountains, the Appalachian Mountains, Mexico, Central America and the eastern side of the Andes in South America. Siberia, the Himalayas and even eastern Africa have great expanses of these forests. Elevation and temperature identifies this type of forest.

These forest type zones are further classified by the predominate species in each zone. The vegetation present influences soil fertility, water and air quality as well as the diversity of wildlife that can be supported in the ecosystem.

Why do we need forests?

Forests are very important to humankind for products, environmental and intangible benefits. Forests are vital parts of the water, nutrient and carbon cycles that support life on the planet. Trees clean the air, moderate temperature, buffer noise, provide wildlife habitat, protect the soil from erosion, regulate water storage and affect water quality.

Air Trees and all green plants, convert water and carbon dioxide into sugars and release oxygen as a by-product through photosynthesis. An acre of trees can give off enough oxygen for 14 people daily. Too much carbon dioxide is considered a pollutant. Through the photosynthesis process, trees "lock up" carbon until the tree dies and decay slowly releases the carbon. An acre of trees can remove 2.6 tons of carbon from the air yearly and even larger amounts of other pollutants. Trees also help manage the amount of particulate mater picked up and carried by wind. Trees serve as windbreaks that slow the force of the wind and prevent topsoil from being blown away. When dust or other particulate matter is picked up by the wind, forests buffer the wind speed so the material can settle back to the ground.

Temperature In the winter, forests buffer winter winds, thus modifying the chill factor. Moisture transpiration in the summer acts as natural air conditioning. An acre of trees can reduce cooling costs up to 30% in 90 degree weather. A large hardwood tree has the cooling capacity of 800,000 BTU's per day, which is equivalent to 20 window air conditioning units running 20 hours per day.

Noise Trees absorb loud noises thus buffering sound. An acre of trees can reduce noise pollution by 50 percent.

Wildlife Forests provide homes for over 400 species of wildlife and thousands of beneficial micro-organisms in Georgia. Certain tree species provide food such as nuts, berries and fruit that sustain wildlife as well as offering shelter. Many species obtain their water needs from twigs and the fruit of trees.

Soil Forests prevent erosion by rainfall and wind. Leaves and needles buffer the velocity of wind and rainfall. The roots and organic litter (dead leaves and needles) protect the soil from being carried away by rain and wind. An acre of trees of any size can conserve up to 100 lbs. of topsoil during a 2-inch rainfall.

Water Trees take up large quantities of water from the soil. Some of it is used in the photosynthesis process and some is used as a solvent to transport minerals and nutrients, but most of it is incorporated in the protoplasm of the tree cells. About 80-90 percent of a tree's weight is water. About 95 percent of the water in a tree is transformed from a liquid into a gas in the transpiration or evaporative process. This is very important to the water cycle. Transpired water is constantly being replaced by water being pumped from the soil. When transpiration occurs faster than water can be brought from the soil, the tree wilts. Transpiration is greater on hot summer afternoons.

Forests also affect the quality of water in our lakes and streams. The roots and dead leaves and needles slow runoff from rain and let the water soak into the soil. This also traps certain chemicals from the atmosphere and prevents them from entering lakes and streams. Without this buffering effect, soil can be carried by runoff into streams, adversely affecting streamflow, water quality and aquatic life.

Products The forest products industry has found uses for nearly every part of a tree, so virtually nothing is wasted when a tree is harvested. Trees larger than 8 inches in diameter, if they are of suitable quality, are normally used for lumber and veneer. Larger trees unsuitable for solid wood products can be used to make paper, particle board and a number of other products. Cellulose and natural wood chemicals are extracted and used to make everything from plastics and food flavorings to photographic film and chewing gum. Bark is useful for producing dyes, adhesives and medicines as well as ground or chipped for garden mulch or burned in furnaces to generate energy. Leaves and needles are used for pine and cedar oil but are generally left in the forest to replenish the soil. Over 5,000 different products we use every day either come from trees or use some by-product of a tree in its manufacture. Some of these products are:

asphalt	toothpaste	paper products	hairspray	paint
charcoal	printing ink	M&M's	eye shadow	dye
artificial vanilla	maple sugar	flooring	rayon	sponge
ice cream thickeners	maple syrup	plywood	solid alcohol	fuel
adhesives	varnish	shoe polish	shingles	pencils
shoe heels	food preservatives	telephone poles	sausage casings	oil
tool handles	popsicle sticks	furniture	shatterproof glass	tea
chewing gum	cellophane	photographic film	artificial hair	paper

Ecological Succession

Objectives

1. Understand how forests change ecologically.
2. Recognize disturbances that effect succession.
3. Identify the major stages of succession.
4. Understand how succession affects energy flow.
5. Identify tree species characteristic of Georgia's ecosystems.
6. Understand why we need to identify trees.

How Forest Ecosystems Change

Forest ecosystems are often disturbed by natural and human activities such as tornadoes, floods, landslides, disease, fires, clearcutting and development. Disturbances do not mean the end of a forest ecosystem. In fact, disturbance is the major force in establishing and maintaining vegetational compositions in ecosystems. Through natural or ecological succession, a forest is regenerated. Natural succession is the way forests change. It is the orderly and predictable replacement of plant and animal species through time. These changes occur as a result of biological, chemical and physical processes acting alone or in combinations. However, one ecological community of species may take decades or even centuries to completely replace or succeed another ecological community of species.

Forested land quickly loses its soluable nutrients and minerals after disturbances such as clearcutting, landslides, and soil erosion. Nitrogen is one of the most important nutrients for forest regeneration. Certain pioneer species restore nitrogen back into the soil after a disturbance. Red alders and black locust are such tree species. Trees need nitrogen to grow, but most species can neither generate their own nitrogen nor obtain it from the air. They must rely on nitrogen compounds in soils. Red alders and black locusts, however, have nodules covering the surface of their root systems containing nitrogen-fixing bacteria that convert atmospheric nitrogen into a chemical form usable by plants. When the alder or locust decomposes, this usable nitrogen is added to the soil's nutrient supply and becomes available to successive plant species.

The dynamics of change in a forest is so slow that most people do not recognize it. Change in a forest may be modified but not stopped. All forests are moving toward a predetermined forest type (climax) through natural succession. Succession can be observed in abandoned fields. During the first year, the site will be dominated by grasses and some annual weeds or wildflowers. The second year perennial weeds or wildflowers as well as pine seedlings appear on the site. The second and third year, hardwood sprouts may begin to appear, but the pines will dominate because they grow faster. Over a period of 10-20 years, many of the grasses and weeds will die out under the shade of the pines. Hardwoods that are shade tolerant will survive as shrubs or small trees beneath the pine canopy. The life span of southern pines is generally less than 200 years although most individual trees will die long before they reach that age. As pines succumb to

natural causes, light reaches the forest floor stimulating the growth of hardwoods that have survived in the pine forest. They respond by growing to fill the places once occupied by the pines. Pines are intolerant of shade, so young pine seedlings cannot compete with the hardwoods so a predominantly hardwood forest is the result. As plant composition changes in an ecosystem, there is usually a change in animal species also. Farming, fertilization, irrigation, herbicides, burning and mowing are used to prevent forest regeneration from occurring in croplands, cities and residential yards.

Stages of Succession

Each forest type has its own identifying species for each state of succession. There are three main stages of succession. These are *primary*, *secondary*, and *climax*. Each stage has phases that chronicle the progression of species. The following pictures illustrate this course for Georgia's Piedmont.

Primary Succession is the first stage of succession in any ecosystem. It begins where the landscape lacks vegetation and fertile soil.

Late Primary/Early Secondary is a phase of succession characterized by "pioneer" species. These include fungi, lichens and mosses, then ferns and grasses. Seeds carried by animals or the wind take root. Pines are among the first pioneer tree species to appear in the southern ecosystems.

Secondary Succession in Georgia begins as a young pine forest. Small mammals, birds and deer live here. There are three phases of secondary succession shown on this page.

Mature Pine Forest Pines die out and hardwoods take over as the dominant species. This is still secondary succession. Usually, the first hardwoods to appear in the piedmont forest ecosystems are sweetgum and yellow poplar which are shade tolerant.

Mature Hardwood Forest Years go by and hardwoods take over as the dominant species. A mixture of hardwoods including oaks and hickories are present in the mature hardwood forest on the left. Wildlife supported in this forest includes bear, raccoon, squirrels and birds. This is late secondary succession and is the most common phase seen on the Chattahoochee National Forest in north Georgia.

Climax This is the final stage of succession. It is relatively stable under existing climate and soil conditions. It is characterized by large, old oaks and hickories in the southeast. This forest supports a variety of plant and animal species in the canopy, lower canopy and the shrub/understory. There is very little forest in the United States in this stage of succession. It is usually limited to small pockets of forests in protected areas and parks.

Disturbance Different phases and stages of natural succession are interrupted by many factors such as tornadoes, floods, fire, disease, earthquakes, timber harvesting, and other activities to meet human needs. Each disturbance takes the landscape back to the earlier stage of succession.

How Succession Affects Energy Flow

Green plants are the only living things which directly capture the sun's energy. Through the process of photosynthesis plants make food and give off oxygen as a by-product. This energy is transfered from the sun to plant and animal eaters through the food chain. In terms of overall flow of sunlight energy on earth, life is arranged in pyramids. That is, a broad base of plants supports fewer and fewer animals as the pyramid of captured sunlight energy flows upwards through the plant and animal life in an ecosystem. It takes about ten times more plants at the base of a pyramid to support the animals at the next level. And those animals will only be able to support l/10th of their number in the level above them.

As energy flows along the food chain, much of it is used up and lost. Plants use much energy to grow as do animals. Even more energy is used as animals move around. Because of this energy loss, there is less energy available farther up the consumer chain. In most ecosystems there are many plants, fewer plant-eaters, and even fewer animal-eaters.

As energy flows through a forest, some of the energy is used to produce new plant tissue through photosynthesis and some of it is used to maintain the physiological functions. For example, a forest's annual gross productivity might be one million tons of plant tissue while its normal respiration might be 200,000 metric tons, making its net productivity 800,000 metric tons.

As a forest succeeds towards climax, increased amounts of energy are used in biomass maintenance rather than in production. Thus, in the climax ecosystem, maximum biomass is supported per unit of energy flow. Since biomass represents stored energy, power output is maximized in the climax ecosystem. Production and respiration are low in an old-growth climax forest which is slow-growing. Accumulated biomass is high and of good quality. Only a little energy escapes from the forest. Even the temperatures are relatively cool and steady.

Species Characteristic of Georgia's Ecosystems

Mountains This physiographic province is commonly called the Appalachian Highlands or Blue Ridge geomorphic province. It was formed by faulting and uplifting of resistant, crystalline bedrock. Elevation ranges from 1,000 to over 6,000 feet above sea level in this province which extends into southern Pennsylvania. However, Georgia's highest peak is only 4,784 feet. Mountains are rounded and generally lack prominent angles. Soils are moderately deep and medium textured and generally receive adequate moisture for growth of vegetation throughout the year. The predominant vegetation is oak-pine and oak-hickory broadleaf forest. The following is a list of common tree species and fauna found in this province in north Georgia.

Trees

Black locust *(Robinia pseudoacacia)*
Chestnut oak *(Quercus prinus)*
Eastern white pine *(Pinus strobus*)
Eastern hemlock *(Tsuga canadensis)*
Northern red oak *(Quercus rubra)*
Post oak *(Quercus stellata)*
Red maple *(Acer rubrum*)
Scarlet oak *(Quercus coccinea)*
Shortleaf pine *(Pinus echinata)*
(largest
Virginia pine *(Pinus virginian*
White basswood *(Tilia heterophylla)*
White oak *(Quercus alba)*
Yellow buckeye *(Aesculus octandra)*
Yellow poplar (*Liriodendron tulipifera*)

Fauna

Black bear
Blackburnian warbler
Gray squirrel
Cottontail rabbit
Pileated woodpecker
Screech owl
Whitetail deer
Various species of salamanders (one of the richest diversity of salamanders in North America)

The average precipitation is 40 to 60 inches in the mountains but ranges up to 80 inches on the highest peaks. Parts of the southern Blue Ridge mountains bordering the piedmont averages over 80 inches of rainfall yearly, which is the highest in the eastern United States. Relatively little precipitation falls as snow. Mean annual temperature is 50 to 62 degrees F and ranges from 38 degrees F in January to 76 degrees F in July. The growing season lasts 150 to 220 days, but varies according to elevation and the influence of local topography.

There is a high density of perennial streams and rivers with moderate rates of flow, however some streams and rivers in areas of high rainfall have considerable velocity and "white" water. The mountains have several major river basins of critical importance to the state. These are the Tennessee, Coosa, Savannah and Chattahoochee.

Fire, wind, ice, and precipitation are the main causes of natural disturbances in the mountains. An introduced pathogen, the chestnut blight, killed all the American chestnuts from 1920 to 1940 and the species has not come back. The Gypsy moth has the potential to cause a major impact because of the dominance by oaks. Natural vegetation has been cleared for agriculture and urban development on about 35 percent of the area, mostly in valleys between major mountain ranges. Tourism is a major part of the economy and the retirement and part-time resident community has increased rapidly in the past few years.

Piedmont This province is irregular plains. High and low hills make up only 30 percent of the area. Elevations range from 330 to 1,300 feet. Soils are generally deep, with a clayey or loamy subsoil. In many areas soils are severely eroded as a result of past intensive agricultural practices, especially for cotton production.

Predominant vegetation is the evergreen forest with rounded crowns. The northern piedmont is about an equal mix of hardwoods and with a dogwood and sourwood understory. The following is a list of common tree and wildlife species found here.

Trees

American holly (*Ilex opaca*)
American sycamore (*Platanus occidentalis*)
Black cherry (*Prunus serotina*)
Black locust *(Robinia pseudoacacia)*
Flowering dogwood (*Cornus florida*)
Loblolly pine (*Pinus taeda*)
Mockernut hickory (*Carya tomentosa*)
Pignut Hickory (*Carya glabra*)
Post oak (*Quercus stellata*)
River birch (*Betula nigra*)
Sassafras (*Sassafras albidum*)
Shortleaf pine (*Pinus echinata*)
Southern red oak (*Quercus falcata*)
Sweetgum (*Liquidambar styraciflua*)
Winged elm (*Ulmus alata*)

Fauna

Bobwhite
Box turtles
Cardinal
Carolina wren
Cottontail rabbit
Eastern chipmunk
Fox squirel
Gray squirrel
Gray fox
Pine vole
Raccoon
Short-tailed shrew
Wild Turkey
White-tailed deer

The average precipitation ranges from 45 to 55 inches in the piedmont. Temperature averages 58 to 64 degrees F. The growing season lasts about 205-235 days. There is moderate density of small and medium size perennial streams and associated rivers. These have moderate flow rates with moderate velocity. The Chattahoochee, Coosa, Flint, Ocmulgee, Oconee, Ogeechee and Savannah River basins drain the piedmont.

Agriculture and fire have been the principal historical disturbances in the piedmont. Summer droughts, winter ice storms, tornadoes and insects such as the southern pine beetles have kept most of this area from reaching its climax vegetation. Most of the area was cleared for cotton production in the 1800's and today urban development is the greatest threat to the forests here.

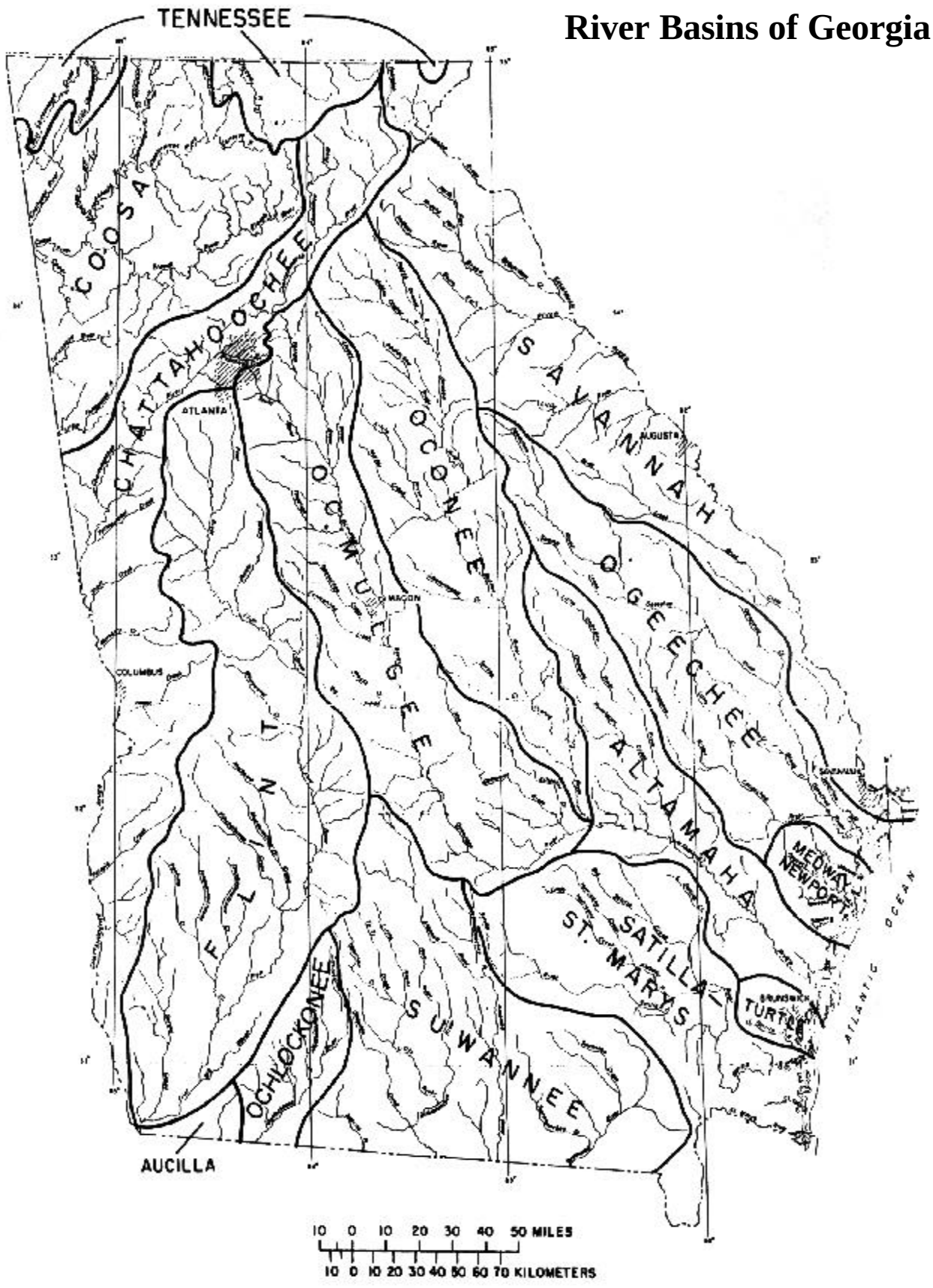
Upper Coastal Plain This province is about 80 percent plains of marine origin formed by deposition of continental sediments onto the submerged, shallow continental shelf, which was later exposed when the sea level subsided. Elevations range from 80 to 650 feet. Soils are generally deep, well to poorly drained and have adequate moisture for vegetation during the growing season. Soils are loamy or sandy in the surface layers with loamy or clayey subsoils. The climax species here are oak-hickory-pine forest but the predominate forest is evergreen. The following is a list of common trees and fauna supported here.

Trees	**Fauna**
American Elm (*Ulmus americana*)	Bobwhite
Bitternut Hickory (*Carya cordiformis*)	Blue-gray gnatcatcher
Eastern redcedar (*Juniperus virginiana*)	Box turtle
Flowering dogwood (*Cornus florida*)	Cardinal
Green ash (*Fraxinus pennsylvanica*)	Common garter snake
Loblolly pine (*Pinus taeda*)	Cotton mouse
Mockernut hickory (*Carya tomentosa*)	Hooded warbler
Pignut hickory (*Carya glabra*)	Mourning dove
Red maple (*Acer rubrum*)	Summer tanager
Shortleaf pine (*Pinus echinata*)	Tufted titmouse
Southern red oak (*Quercus falcata*)	Wild Turkey
Sweetgum (*Liquidambar styraciflua*)	White-tailed deer

Rainfall averages 40 to 60 inches annually and the temperature averages 60 to 68 degrees F. The growing season last from about 200 to 280 days. There is a moderate density of small to medium perennial streams and rivers, most with a moderate volume of water at low velocity. It is drained by many of the same river basins as the piedmont with the addition of the Altamaha. These are the Coosa, Chattahoochee, Flint, Ocmulgee, Oconee, Altamaha, Ogeechee and Savannah.

Like the piedmont, agriculture and fire have been the principal historical disturbances. Summer droughts, winter ice storms and tornadoes occasionally damage the forests in the upper coastal plain. The southern pine beetle insect infestations often cause much damage to forest stands. Natural vegetation has been cleared on about 30 percent of the area for agriculture.

River Basins of Georgia



Lower Coastal Plain This flat, alluvial plain was formed by deposition of continental sediments onto the submerged, shallow continental shelf, which was later exposed when the sea level subsided. Elevation ranges from 0 to 80 feet above sea level. Soils are deep, finely textured and have adequate to excessive moisture supply for vegetation during the growing season. The climax forest is oak-hickory-pine, but the predominant species are evergreens. See the list below for trees and fauna you might expect to find in this ecosystem.

Trees	**Fauna**
Baldcypress (Taxodium distichum)	Box turtle
Flowering dogwood (Cornus florida)	Cormorant
Laurel oak (Quercus laurifolia)	Cottontail rabbit
Live oak (Quercus virginiana)	Eastern indigo snake
Lololly pine (Pinus taeda)	Egret
Longleaf pine (Pinus palustris)	Gopher tortoise
Red mulberry (Morus rubra)	Heron
Slash pine (Pinus elliottii)	Ibises
Southern magnolia (Magnolia grandiflora)	Kingfisher
Sweetbay magnolia (Magnolia virginiana)	Ruby-throated hummingbird
Water hickory (Carya aquatica)	Summer tanager
Water oak (Quercus nigra)	Striped skunk
Yellow poplar (Liriodendron tulipifera)	Swamp rabbit

Annual precipitation averages about 46 inches. Temperature averages 55 to 57 degrees and the growing season lasts 185 to 220 days. There is a moderate density of small to medium size perennial streams and a low density of rivers. Most have a moderate volume of water at a very low velocity. The water table is high in many areas, resulting in poor natural drainage and an abundance of wetlands. The major river basins include the Savannah, Ogeechee, Medway-Newport, Altamaha, Satilla-St. Marys, Turtle, Suwanee, Ochlockonee and the Aucilla. Fire and hurricanes are the main disturbance regimes, but the southern pine beetle insect infestations destroy thousands of acres of pine forests in this region.

It is important to note, that the species list included under each region is only a fraction of the tree and wildlife species supported in each of the physiographic provinces. The lists given are the most common species in that area. Notice many of the species are found throughout the state. These species have adapted very well to the differences in rainfall, soil types, temperatures and elevation found from the north to south Georgia. The broad ecoregions described here can be further divided into sections.

Tree Identification

Why should we learn to identify different trees? Different species of trees grow close to water, on high ridges, in different soil types, etc. It is very important for foresters to know the species makeup of the forest. On public lands, botanists inventory plant communities in the forest

before any timber management action that could adversely affect the ecological relationships are undertaken. Threatened or endangered species may exist in an area to be harvested so measures must be implemented to protect these species. This usually means creating a buffer zone where no harvesting will take place around such species.

Cultural resource surveys are also conducted to determine prehistoric and historic uses of the land before ground disturbing management activities begin. Significant cultural findings are also protected. Often trees help date an archaeological site and the type trees found at the site may give clues to past land use.

Knowing species composition is important for prescribed burning and smoke management. Different plant materials burn at different temperatures and some plants such as poison ivy release oils when burned in the smoke. If this smoke is inhaled, it can cause serious and even fatal lung infections. Different species of trees have different economic value both for lumber and other uses. This is always changing. In the early l980's, the Pacific Yew had little economic value. In fact, it was considered a "weed" species in the northwestern forests. Then the cancer fighting drug, "taxol", was discovered, which is only derived from the bark of the Pacific Yew. Needless to say, this tree is now quite valuable.

All trees can be classified into two specific families--gymnosperms and angiosperms. Gymnosperms are generally the conifers, or cone bearing trees and for the most part, are evergreens. Gymnosperms bear naked seeds; often on a scale. Angiosperm seeds, in contrast, are enclosed by the ovary. Angiosperms include hardwood trees and are mostly deciduous, meaning they shed their leaves in the fall. Trees are identified by their seeds, shape of their leaves or needles, the arrangement of the leaves, bark and even shape of the crown. Additional identifiers are their flowers, fruits, habitat, taste or smell. It takes observation, study and practice to correctly identify trees. There are many common names for the same tree that varies from one locale to the next. For technical accuracy, to eliminate language barriers and facilitate effective communication, the scientific name classification was developed. The development of a universally accepted system using scientific names has resulted in more effective communication among scientists and has furthered research.

Forest Management

Objectives

1. Describe how and why forestry began in the United States.
2. Identify forest managing agencies.
3. Understand how a tree grows and how leaves change colors.
4. Know how to determine the age of a tree.
5. Know how trees are measured for market.
6. Identify forest management methods.

History of Forestry

The study of forestry first began in Germany in 1770, and spread to France in 1824. The United States expressed little interest in forestry schools or in applying scientific management to forest lands until the late 1800's. The pioneers found America blessed with thousands of acres of mature and climax forests so vast it was thought the resource was endless, so little, if any thought was given to replanting as trees were cut down. It was not until Dr. Carl A. Schenck, a German Forester came to America to manage the Biltmore Estate forests in North Carolina did people realize what was happening by overharvesting. Schenck started America's first forestry school near Asheville. Here he taught woodsmen conservation of forest resources. Another conservation leader was Gifford Pinchot who is often called the father of American Forestry. He convinced Americans that our forests are renewable resources and proved, on the Biltmore Estate Forest in Asheville, North Carolina that good forestry management could produce a perpetual timber harvest.

The first government forestry organization, The Division of Forestry which was under the Department of Interior, was established in 1880. Bernhard Fernow was its head. This fledgling agency advocated government action to protect natural resources in a rational manner. In 1901, the Bureau of Forestry was established and Gifford Pinchot was named its chief in charge of the recently created Forest Reserves. These reserves were lands set aside by the Creative Act of 1891 from public domain as permanent reservations for eventual use as forests. In 1905, the Bureau of Forestry was transfered to the Department of Agriculture and renamed the Forest Service.

The USDA Forest Service

The Forest Service was placed under the Department of Agriculture because it grows trees. Most of the land that is National Forests today in the East, was purchased from willing sellers because it was land no one wanted. It had been cut-over, mined, over-grazed, over-farmed or otherwise abused. It was the task of the Forest Service to restore the land by planting trees to protect the watershed and properly manage the land so that a continuous supply of timber could be assured.

Since the agency was established, its role has greatly expanded. The Forest Service develops and maintains recreation facilities and opportunities on the 154 National Forests, manages wildlife and fisheries habitat and protects the forests from fire. In recent years, protecting air and water quality are receiving increased emphasis. The Forest Service also cooperates with state forestry agencies such as the Georgia Forestry Commission to encourage good management of privately owned forests including urban forests. The Research branch of the Forest Service conducts studies, experiments and tests to find better ways of managing trees, develop and/or improve forest products, insect and disease control, fish management and even ways to recycle forest products. Professionals from many disciplines are required to perform these tasks and to carry out the agency's mission of caring for the land and serving people.

The Chattahoochee-Oconee National Forests is made up of 750,000 acres in North Georgia stretching from the North and South Carolina borders westward to Alabama and northward to Tennessee. The Oconee contains over 115,000 acres and is located in the piedmont. The Forests are required by law to be managed for water, timber, fish and wildlife, range and recreation which includes wilderness. Ten of the State's congressionally designated wildernesses are located on the Chattahoochee National Forest (about 15% of the forest). Activities that disturb solitude such as motorized vehicles and logging are prohibited in the designated wildernesses.

The Georgia Forestry Commission

The Georgia Forestry Commission is a state agency established after World War II with the responsibility of protecting Georgia's forests and grasslands from wildfire. The Commission uses direct suppression tactics, as well as the installation of presuppression firebreaks, in order to limit the damage done by wildfire. The Georgia Forestry Commission provides citizens with professional advice on forest and natural resource management in both rural and urban areas. Professional foresters aid in administering federal cost-share programs to help defray the cost of getting various types of work done. Examples of such programs are the Conservation Reserve Program (CRP), Stewardship Incentive Program (SIP), Forestry Incentive Program (FIP), and Environmental Quality Incentives Program (EQIP).

The Forestry Commission also operates two tree nurseries in the state, producing over 50 million trees per year for sale to the public. The Information and Education Department supplies educational materials to the public and to over 150 offices throughout Georgia, who conduct over 3,500 educational programs to schools, civic groups and other organizations per year.

Private Industry

Forests are the most predominant feature of Georgia's landscape. Of the 37 million acres of land in Georgia, approximately 24 million acres are classified as timberland. Georgia is the largest timber producing state in the Southeast. Private, non-industrial landowners own 68 percent of all forest acreage in Georgia. The commercial forest industry (timber companies such as Georgia Pacific, Inland-Rome, Weyerhaeuser, etc.) owns 25 percent and the government (federal, state and local) owns 7 percent of Georgia's timberland. This multi-billion dollar industry ships paper and wood products to markets worldwide.

Private Organizations

Much of the forest community belongs to the Georgia Forestry Association (GFA), one of the oldest professional conservation organizations in the United States, founded in 1907. The GFA works with landowners protecting property rights and adopting sound land management practices to ensure that our forests continue to provide our ecological as well as product needs now and in the future. The GFA supports and practices objectives outlined in the Sustainable Forestry Initiative (SFI), one of the most far-reaching changes in forest management and conservation in the history of the United States forest and paper community. Part of these principles are guidelines to protect water quality, wildlife, soil and plant communities when timber is harvested. Over 92 percent of Georgia's commercial forest acreage is in compliance with the guidelines but a goal of 100 percent is the target.

How does a tree grow?

Trees convert carbon dioxide from the air, water and nutrients from the soil into wood through a chemical process known as photosynthesis. The green pigment in leaves, chlorophyl, absorbs energy from sunlight and uses this to combine water from the roots with carbon dioxide from the air to produce sugar (glucose). Glucose is used by the plant for growth. Oxygen is produced as a by-product of this process and is released into the atmosphere. Trees continue to grow as long as there is a spark of life. Even when old and diseased, a tree will endure year after year while dying branch by branch.

Although we cannot see it happening, trees are continuously losing water through their leaves. The undersides of leaves are covered with millions of microscopic openings, or pores, called stomata. These tiny pores open to allow carbon dioxide to move in and oxygen to move out of the leaves. Water vapor also passes out through the stomata in a process called transpiration. A small tree can transpire several hundred gallons of water a day. This is a very important function of the water cycle. The water lost from leaves is replaced by water moving up from the roots through the sapwood.

The trunk of the tree has five main layers, each with a special function.

The Outer Bark insulates and protects the tree. It continually builds outward from the inner bark layer.

The Inner Bark contains phloem cells which carry food from the leaves down through the tree. As it dies, it becomes outer bark.

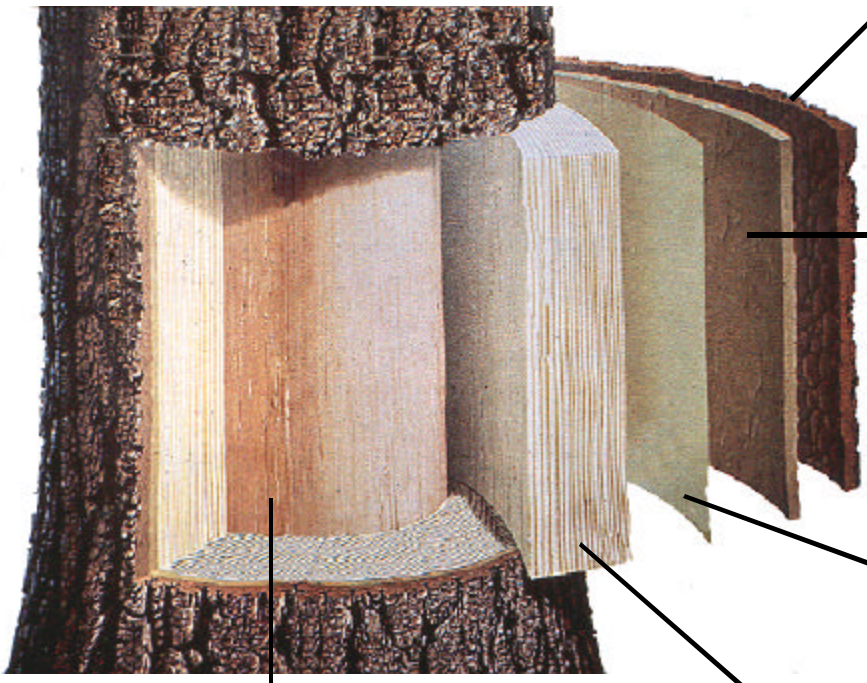
The Cambium Layer is a single layer of cells where all growth takes place. It produces phloem cells for the inner bark and xylem cells for the sapwood.

The Sapwood contains xylem cells, which transport water and nutrients from the roots up to the leaves. It also stores food for growth and seed production.

The Heartwood gives the tree strength. It is dead wood formed by old xylem cells. Heartwood may rot away, leaving a hollow, living tree.

See the diagram on the following page.

Layers of a Tree



Bark covers the outside of the trunk, insulating it and protecting the tree from disease.

Phloem lies just under the bark. This fibrous tissue carries sugar down from the leaves.

Cambium is the thin, life-giving part of the trunk. From it comes all of the other cells.

Sapwood transports water up from the roots. It is usually lighter in color than heartwood.

Heartwood is aged sapwood, and the two together form the xylern. Most of the trunk is heartwood.

How do leaves change colors?

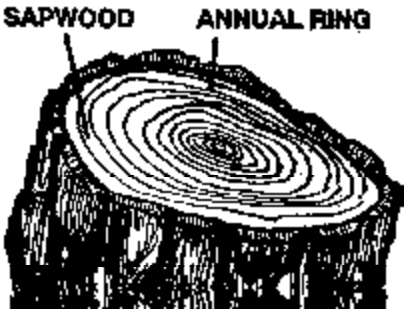
Scientists do not fully understand all of the complicated interactions involving pigments, sunlight, moisture, chemicals, hormones, temperatures, length of daylight, site, genetic traits, etc. that make a perfect autumn color display. The process begins in the fall when the next year's leaf buds are set and continues into spring when pigments develop, through the summer growing season, and, of course, the fall when the colors are displayed. If weather conditions are not optimal during each of these periods, the amount of leaves on the trees will be affected, as well as the color development.

A green leaf is green because it has a group of pigments known as chlorophylls which are essential to plant growth. When chlorophylls are abundant, the green masks out the other pigments present in the leaf. Chlorophylls capture the sun's energy and uses it along with carbon dioxide and water to manufacture glucose. In this process, the chlorophylls are continually being broken down and replenished during the growing season. As autumn approaches, the chlorophylls are replaced at a slower rate than they are used so the other pigments begin showing through. One group of pigments that give the yellow, brown, and orange colorations are carotenoids. Another group of pigments that give the reds, purples and their blended combinations are called anthocyanins. Carotenoids are present all along, but the anthocyanins usually develop in late summer. Their formation depends on the breakdown of sugars in the presence of bright light as phosphate in the leaf is reduced.

In the fall, phosphate and other chemical nutrients move out of the leaf into the stem of the plant. When this happens, the sugar breakdown process changes, leading to production of anthocyanin pigments. If the sunlight is strong and the nights chilly but not freezing, the brightest colorations usually develop.

Fall colors usually move down the Appalachian Mountain chain from the north to the south in waves. The yellow-orange waves first, followed by the red and purple waves. Peak color for the north Georgia mountains is usually around the third week in October. However, in recent years, the peak colors have not developed until the first week in November. There are many speculations and theories to explain this. One that seems to have more supporting evidence than others is that global warming is affecting the color season. Ocean currents appear to have moved further north bringing more rainfall to the mountains. This tends to make the tree hold on to its leaves longer and affects the development and movement of pigments in the leaves. As research probes deeper into our changing environment, more answers will be forthcoming.

How to determine the age of a tree



Tree rings are the annual growth rings produced by the tree. Trees in temperate zones grow one ring per calendrical year. As a tree grows in the spring, the cambium layer produces large, thin-walled xylem cells that form a light-colored ring in the sapwood. Growth slows down in late summer and fall, and the cells are smaller and thicker-walled, appearing as a darker ring. Each light and dark ring together is an annual ring and represents one year of the tree's growth. You can count the annual rings to determine the tree's age. Ring width is very small in old trees. Early or late frosts sometimes promote formation of false rings which do not completely encircle the tree and are not typical of the growth pattern. Annual rings at the base of the tree will give the true age of the tree. Annual rings at the top of the tree give only the age of the top of the tree. Annual rings of a branch give the age of the tree branch. Distinct rings do not occur in all species. Tropical forest species do not clearly exhibit these rings and even some temperate forest species such as red maple and blackgum do not show clearly visible rings.

Foresters may use a threaded, hollow increment borer to extract a pencil-sized core of wood from a standing tree to determine the age and condition and to analyze growth rate of the tree. In coring any tree there is a level of risk associated with the long term effects of the core hole. The degree of risk depends upon the species and the coring process. In all cases, a very sharp corer should be used and core should slope slightly upward so that water, and sap can drain out rather than into the tree. Do not plug holes with dowels or other objects as they increase the rate of stem cracking and cambial dieback. Also do not use wound dressings or paint and do not tag trees with nails or staples. In trees with compartmentalized decay as in heartrot, coring can spread the infection to the sapwood. Softwood (coniferous) trees with their crowns in the canopy and in less crowded conditions are best choices for coring.

The tree core, once extracted from the tree, may be safely carried back to the lab in a plastic soda straw. At the lab, the core should be removed from the straw and allowed to dry overnight. Core is then glued into a narrow board so that the wood grain (annual rings) is on top. After the glue has dried, the core is sanded to remove scratches, resulting in a smooth surface with distinct boundaries between tree rings. To date the core, a dot-marking system is most commonly used. One pencil dot is placed in the ring produced in each decade, two dots on half-

century years and three dots on century years. Using this method, it is easy to quickly find rings produced in certain years.

Tree rings tell us about the tree's history. Wide rings show years of rapid growth, perhaps due to plentiful rain or lots of growing space. Narrow rings represent slow growth caused by drought or stress to the tree. A scar across the rings shows that fire or disease struck the tree. Growth of each 5 or 10 consecutive rings may be measued to the nearest 0.5 mm and then plotted (growth on the Y axis and years on the X axis). Patterns may then be compared to known weather conditions or other environmental phenomena. Growth in certain years may be compared to known droughts or forest fires. The study of tree rings is dendrochronology.

How long do trees live?

Most pines live 80-100 years and hardwoods live 150-250 years in Georgia's ecosystems. However, just as some people live longer than others, so do trees. Every species has its own genetically determined maximum life span. The *maximum* age of some of Georgia's species under optimal conditions which may or may not occur in Georgia follow:

White oak, Sycamore, White pine .....450-600 years
Beech .....300-400 years
Eastern redcedar, Loblolly pine, Tulip poplar,
Sweetgum .....240-350 years
Shagbark hickory .....250-300 years
Northern red oak, Red maple .....150-300 years
Black walnut, Black oak ..... 200-250 years
Black cherry, Shortleaf pine .....150-200 years

The world's oldest living thing is a tree, a Bristlecone pine, which is 4,700 years old. It is called the "Methusselah" and grows atop the White Mountains in the Inyo National Forest in California. Most pines, in the South, do not live much past 80 before disease or insect infestation kills them while some oaks may live 200 years before disease or insects affect them. Other species are dying of "old age" at 80-100 years.

Pines are usually harvested at 30-40 year rotations for pulpwood or sawtimber where they are being managed for this purpose. Hardwoods are harvested at 80-100 year rotations for lumber. This allows the greatest return economically before the trees start their decline. The time of harvest for timber is determined by the product desired. For example, trees managed for pulpwood can be harvested at an early age while high quality sawtimber is harvested after the tree matures. Once the product desired is known, the volume or amount of lumber in a specified area or "compartment" determines the time of harvest.

The smallest measure of volume for timber is a board foot. A board foot is equivalent to a piece of wood 12 inches square (30 cm) and l inch (2.5 cm) thick.

How do you measure standing trees?

The volume of wood in standing trees may be estimated by obtaining three measurements and applying them to tree scale volume tables or a mathematical equation. Measurements needed are diameter, merchantable height and amount of taper in the trunk of the trees. Tree diameter is measured at 4.5 feet above the ground, a point referred to as "diameter breast height" or DBH. Diameter is measured to the nearest inch using calipers, diameter tapes, tree scale sticks or other instruments. One of the simpliest ways to determine diameter without special tools is to measure the circumference at 4.5 feet above the ground with a measuring tape. Apply the formula, $D = C \text{ -:- } \pi$ (Diameter equals circumference divided by pi (3.14). Another method is to use a DBH tape.

Units of Timber Measurement

Trees are placed into different categories depending on their size and form. They are usually placed in three size classes.

Sawtimber 12 inch DBH or greater trees that are of good form and free of major defects. Sawtimber trees are considered your "money" trees and are used to make lumber. Sawtimber is usually measured in board feet or metric tons.

Chip-n-saw 9 to 11 inch DBH trees (conifers only). Chip-n-saw trees are used for smaller lumber and are chipped for planeboard and paper. Chip-n-saw trees are usually measured in cords. One standard cord of wood would make a stack measuring 4' X 4' X 8', or 128 cubic feet.

Pulpwood 6 to 9 inch DBH trees and other poor form trees. These trees are chipped up into tiny chips and used to make paper and the hundreds of other products made possible by pulp. Pulpwood is also measured in cords.

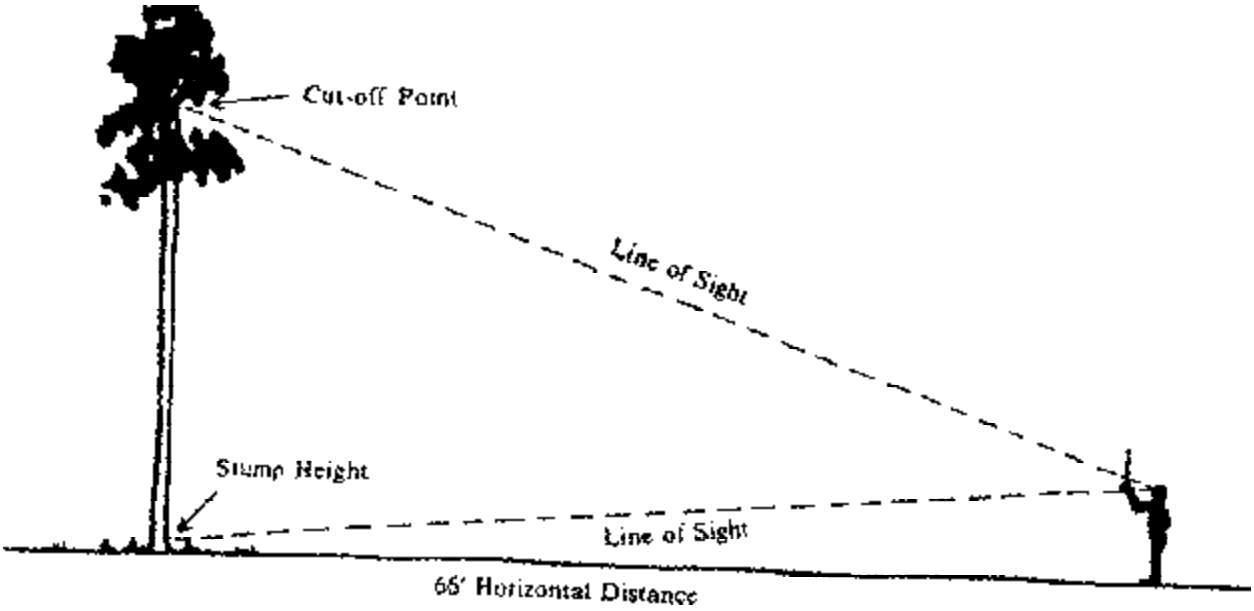
Other Other merchantable timber such as poles and veneer logs are exceptional form class and are measured as high quality sawtimber. Fence posts and pilings are measured like pulpwood. Form class is the percent of taper in a tree and affects the yield.

Merchantable Height

Merchantable height is the usable length of a tree. It is measured from "stump height" to the "cut off" point to the top where the trunk becomes too small in diameter or where excess limbs occur. The cut off point will vary depending on the end use of the logs. For sawtimber trees, standard log length is 16 feet and a half log is 8 feet. The cut off point is where the diameter becomes as small as 7 or 8 inches or where there is a major fork in the tree. A tree with a merchantable height of 40 feet would be recorded as a 2 and l/2 log tree. For chip-n-saw and pulpwood, the merchantable height is measured to the nearest 10-foot class. The cutoff point is where the diameter becomes less than 4 inches. For example, a tree that is measured at 44 feet

would be put in the 40-foot height class and a tree measured 58 feet would be put into the 60 foot class. Most pulpwood is measured as total merchantable height (in feet) and hauled tree length to the mill.

A tree scale tool (Biltmore Stick) or clinometer is used to determine merchantable height of standing trees. The diagram below illustrates a Biltmore Stick being used.



Biltmore Stick

To measure a standing tree with a Biltmore Stick, stand 66 feet from the tree while holding the stick vertically at arms length and shoulder height with side B facing you. Line up the bottom of the stick with the base of the tree. Count the number of logs illustrated on the stick. The logs illustrated on the stick are usually 16 ft. logs. It is important not to move the stick when taking a measurement. Tilt your head back slightly so that the stick does not have to move when reading from ground to top of the tree.

Take a second height measurement with the Biltmore Stick. This time, measure from the stump height to the cut off point in the top. The cut off diameter will vary with locality, with product being produced, and with excessive limbs, but is usually between 4-10 inches. The minimum diameter log that can be used in the sawmill determines the cut off diameter.

Clinometer

A clinometer is an instrument that allows you to do sighting and scale reading simultaneously. Readings are usually taken with the right eye but this is a matter of personal preference. It is very important that both eyes are kept open when taking the readings. The supporting hand must not obstruct the vision of the other eye.

The clinometer is held before the reading eye so that the scale can be read through the optics and the round side-window faces to the left. The instrument is aimed at the tree by raising or lowering it until the hair line is sighted against the point to be measured. At the same time, the position of the hair line against the scale gives the reading. The left-hand scale gives the slope angle in degrees from the horizontal plane at eye level. The right-hand scale gives the height of the point of sight from the same horizontal eye level, and it is expressed in percent of the horizontal distance.

To take height measurements on level ground using the percent scale and 80' baseline (or other baseline), back away from the tree the baseline distance. Sight the top of the tree and read the % scale, then sight the bottom of the tree and read the % scale. Add the two distances. Multiply this total percentage times your baseline distance to get your tree height.

To take height measurements on sloping ground using the percent scale, when the base of the tree is ABOVE eye level, sight the top then the base. Subtract the two readings, then multiply by the baseline distance to get tree height. When the base of the tree is BELOW eye level, sight the top, then the base and add the two readings, then multiply by the baseline.

Using forestry tools accurately requires practice. Seek help to thoroughly understand the proper techniques and methods.

Calculating Board Feet

The amount of taper in a tree affects the yield. Taper is where the tree gradually becomes smaller toward the top. It is expressed as a percent and is called “form class”. It is measured in the field using DBH and the diameter (inside the bark) at the top of the first 16-foot log. For example if the tree measures 12" DBH and 9.6" inside the bark at the top of the first 16-foot log, the form class is 80%. See the formula below.

$$\text{Form class} = \frac{\text{Diameter inside bark at top of first log}}{\text{DBH}} = \frac{9.6}{12"} = .80$$

Bark is considered to be approximately 1 inch of the tree.

The Scribner Log Rule (table) is usually used by most foresters to determine board feet of pine trees after the measurements have been taken. The Doyle Log Rule (table) is traditionally used to determine the board feet of hardwoods because of the way it handles taper. Hardwoods usually have more taper than pines. There are a number of Tree Rules or tables that can be used for determining board feet. However, the Scribner and Doyle are most often used by foresters.

Tally cards

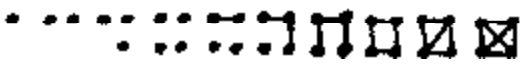
Data field recorders are types of computers that have replaced tally cards in most large forestry operations. With these, measurements can be entered as they are taken in the timber stand. Total volumes are given instantaneously by the touch of a key. Many foresters, however, use tally cards to record the diameters and heights of the trees. The total number of trees in each category are counted and then multiplied by the volume of wood in each tree. That number, in turn, would be "blown-up" according to the number of acres being sampled to determine total volume in a stand. The use of tally cards is still taught in forestry schools and tally cards are used by foresters in smaller plots or compartments. A sample tally card is included with this study unit.

The *dot-dash tally method* is used to record the number of trees by species, dbh and merchantable height on tally cards. It is somewhat tedious but it requires no electricity or batteries and is a reliable backup in time of computer failures. Here is an example of how the dot-dash tally method works.

dbh (INCHES)	TREE HEIGHT CLASSES (FEET)					TREE TOTALS
	20	40	60	80	100	
10	⁘					3
12	⁘	⁘				6
14	•	⁘	⊓	⁘		13
16		⁘	⊠ ⁘	⊠	⁘	27
18		•	⁘	⊔ ⁘	⊡	17
20			•	⊓ ⁘	⊠	16
TREE TOTALS	6	10	24	23	19	82

DOT-DASH TALLY METHOD

1 2 3 4 5 6 7 8 9 10



Weight Scaling

The trend toward buying timber by weight is strong in the South today and appears to be getting stronger. Sawlogs, pulpwood, poles, fence posts and other products traditionally bought by board feet, cords or by other standards, are being sold by weight in many areas. The increased interest in weight-scaling is due to the following reasons:

* Human judgment does not enter the picture.

* Weighing is quicker than scaling, saving time for both buyer and seller.

* It encourages prompt delivery of green wood to the mill, desirable from the processing standpoint.

* A greater volume of wood can be handled in less time with less personnel and inventories are more easily maintained.

The conversion from traditional standards of measurement to weight measurement, however, brings up many questions. For instance, is the weight basis fair to both buyer and seller? What are the exact weight equivalents for a thousand board feet of sawlogs or a cord of pulpwood? Many of these questions cannot be answered because of the variables associated with wood itself.

Pulpwood

A standard cord is a stack of wood whose gross volume equals 128 cubic feet. Gross volume includes solid wood, bark and air. The amount of solid wood in a cord is affected by stick diameter, length, bark thickness and quality, and may vary from 50 cubic feet for small sticks to as much as 105 cubic feet for straight wood 8 inches in diameter and larger. Studies covering the entire South assume an average cord of pine to have 72 cubic feet of solid wood and hardwoods, 79 cubic feet. These variables, plus differences in methods of scaling show that measuring wood by volume methods can be unfair to either buyer or seller.

Weight-scaling pulpwood also has certain disadvantages. The primary disadvantages are the variables that exist between species as well as within species. Factors influencing variations in weight are:

* Density - Volume for volume, wood density varies between species as well as within species and is readily affected by percent of summer wood, rate of growth and position in the tree.

* Moisture content - The moisture of wood varies among species and within species between heartwood and sapwood.

Several pulp companies have developed average weights per cord, taking into account the above factors and are using these weights today. The weight equivalents vary by species, mills and localities or points of origin. Weights per cord currently being used by pulp companies in the Southeast average 5,232 pounds for pine and 5,758 pounds for hardwood. These weights vary from 4,800-5,600 pounds for pines and from 5,000-6,100 pounds for hardwoods.

The current practice in buying pulpwood by weight is to pay for it on a hundred-weight basis. For an individual to lose a dollar on a cord of wood worth $16.00 at the yard or mill, the values being used by the pulp companies would have to be approximately 400 pounds below the average.

Sawlogs

The advantages of buying sawlogs by weight are essentially the same as for pulpwood. The disadvantages are log quality and size cannot be determined by weight. Knotty, crooked logs may weight the same as clear, straight logs. Also, a truckload of small logs may weigh the same as a truckload of large logs but yield less lumber per unit of weight.

Several studies have been made throughout the South to determine weight-volume relationships of southern pine logs. These studies conclude that the most accurate weight-volume data are those developed by a specific mill for its own use. Because utilization practices and other factors affect lumber yield, data obained by one mill would not necessarily apply to logs procured by another mill.

Georgia sawmills, buying by weight, use average weights from 12,000-17,500 pounds per thousand board feet of sawlogs. The size and species of logs are the primary factors to consider when selling sawlogs by weight.

Forest Management Methods

Silviculture is the art and science of managing and tending a forest. When a series of cultural practices are planned into the long-term management of a forest stand, the total program is a silvicultural system. This system has implications throughout the life of the stand. The system usually takes its name from the final harvest method such as clearcut, seed tree or shelterwood. Planning a system depends on the objectives, the tree species and the land itself. For example, mountain land would not be suitable for growing baldcypress and deep coastal plain swamps would not support white pine. One objective might be to grow only pine pulpwood, another to grow high quality sawlogs. Management objectives should also include non-timber purposes such as wildlife, watershed, scenery, etc.

Determining the length of time between establishing the stand and the final harvest is called the rotation or rotation age. Pulpwood would have a rotation of 20-30 years, small sawtimber 30-50 years and large sawtimber 50-80 years. Prescribed burning, a system of burning the underbrush and forest litter buildup, as well as regular thinning are appropriate silvicultural tools in southern pine stands but are not usually recommended for hardwood stands.

There are basically two silviculture management systems, *even-age* and *uneven age management*. Both these systems mimic disturbances that occur in natural succession. For instance, sometimes wind, fire, ice storms or disease and insect infestation can kill a forest in a short time. When the forest regrows, the new trees are all about the same age, even though size may vary with growth rates. This type of forest is called "even-aged". Other times, a forest may grow for many years with only small groups or individual trees dying. This provides open spaces that soon will be filled by young trees. These forests are called "uneven-aged".

Over time, each type of forest will take on a different appearance. Certain trees, such as black cherry, oak, hickory and pine, grow best if they are managed as even-aged forests because they have high needs for direct sunlight. Other trees, such as hemlock, maple, dogwood, and beech, can thrive in the shaded environment of an uneven-aged forest. As with the different stages of natural succession, each type of forest supports different wildlife habitats. To imitate nature's methods of regenerating forests, different cutting practices are used for each.

Cutting methods for even-aged mangement:

Clearcutting removes all merchantable trees from a specific area at one time, except trees reserved for special purposes, such as wildlife habitat. This maximizes available sunlight for new tree growth and benefits many species of wildlife that browse on young vegetation and soft mast. Reforestation can be accomplished by natural regeneration, sowing seeds across the land or planting seedlings. Planting allows the manager to control the species and spacing between trees. Planting also gives the option of planting genetically improved seedlings which grow faster and are more resistant to disease. Unlike ornamental trees or shrubs, forest tree seedlings are most frequently planted in winter and early spring. This allows the seedling to become acclimated to its new environment during the dormant season, thus reducing the shock of transplanting and competition for nutrients.

Shelterwood cutting removes forty to sixty percent of the trees, allowing new trees to become established in partial sunlight under the shelter of the remaining older trees. Following the establishment of new trees, remaining older trees should be removed.

Seed tree cutting removes most of the trees in one cut, leaving a few, well-spaced good seed producers over the area. This method is used mostly in pine stands. In the early life of the stand, it will be protected from wildfire, insects and disease, with thinning and improvement cutting done. Prescribed burning will probably be conducted every 3-5 years. About five years before the end of the rotation, prescribed burning is done more frequently to keep brush to a minimum and expose patches of mineral soil on the forest floor for seeds to germinate and grow. On every acre, 10-12 of the very best trees are selected and clearly marked. These seed trees will be the parents of the new forest. When the rotation age is reached, all trees are harvested for market except the seed trees. Seed trees are not harvested until a new forest has been adequately established.

Cutting methods for uneven-aged management

Group selection cuts small groups of trees in one-quarter to two acre plots. This creates larger openings for regeneration of trees which require partial sunlight.

Individual tree selection cuts trees of various sizes, dispersed throughout the forest individually selected for cutting. This creates small openings for establishment of shade tolerant species.

Coppice System

The coppice system is a forest originating mainly from sprouts or root suckers rather than seed. This is viable for hardwoods, and can be used for both the even and uneven age management of forest stands. When a hardwood tree is cut, dormant buds beneath the bark of the stump are stimulated. New sprouts grow from these buds, frequently resulting in a clump of new trees all coming from one stump. These new sprouts grow rapidly because they are still served by the large root system of the parent tree. There are many variations of the coppice system. The most basic method is to harvest a hardwood stand and allow nature to take its course. Another method is to harvest, wait for sprouts to appear, then remove all but one healthy sprout from each stump.

Prescribed burning

Woods burning under controlled conditions and for a particular purpose is called "prescribed burning". It differs from a wildfire in that it is intentionally set and controlled to achieve a specific goal. The reasons for burning include the following:

Hazard reduction - The accumulation of litter and undergrowth in unburned forest stands increase the threat of wildfires. Such fires can seriously damage stands of all ages. Periodic prescribed burning can make them practically immune to destructive wildfires.

Hardwood control - Low value, poor quality hardwoods and shrub species often invade pine forests. They prevent successful pine regeneration and compete with the pines for available nutrients and moisture. A series of prescribed fires can be effective in minimizing this competition.

Site preparation - Pines need bare soil and full sunlight to regenerate and grow. Fire helps to provide these conditions for natural regeneration. It also reduces the cost of site preparation by mechanical or chemical means when trees are to be planted.

Wildlife habitat improvement - Many game and non-game wildlife benefit from prescribed burns. Predator cover is reduced, hidden seeds exposed for food, soil nutrients released and the production of herbs and legumes is stimulated.

Disease control - Certain tree diseases such as annosus root rot and brown spot needle blight of longleaf pine seedlings can be controlled by prescribed burning.

Improve accessibility - Removal of excess underbrush by prescribed burning improves accessibility and visibility. It aids in marking and cruising timber, harvesting operations and marketing timber.

To be successful, prescribed burning requires advance planning. First, smoke sensitive areas near the burn must be determined. These are places where reduced visibility or smoke irritation to livestock and humans could cause material loss and suffering. Examples of smoke sensitive areas are airports, highways, communities, resorts, recreation areas, schools, hospitals, factories, stock barns, etc. Do not burn if a sensitive area is within three-fourths of a mile down-wind of burn. Wait for a wind from a different direction. Do not burn if area already has an air pollution or visibility problem. Burn only when vertical dispersion is good. Do not burn at night as temperature inversions and lack of wind holds smoke down. Visit the site to be burned to determine tree stand height, relative amount of fuel (leaves and needles or thick undergrowth) on the ground. Locate firebreaks where fuel and stand conditions change. Use roads and natural barriers where possible. County fire protection units will plow firebreaks for a nominal fee per hour.

The best time of year to prescribe burn an area is in the winter. Weather conditions are more predictable, stable and temperatures are usually cooler. Burn following the passage of a cold front when a steady northerly wind of 4 to 10 miles per hour can be counted on to dissipate the heat and smoke. Relative humidity should be between 30 to 50 percent. Forest litter should feel dry to the touch but the soil beneath should be damp. When relative humidity is lower than 30 percent, burning is very dangerous. Always confirm weather forecasts and check with the local Forestry Commission before burning.

Sustainability of Forests

Objectives

1. Define sustainability.
2. Understand the role of technology in furthering sustainability.
3. Distinguish between economic and eco-nomic values of forests.
4. Understand sustained yield.
5. Identify insects and diseases affecting sustainability.
6. Assess methods for controlling insects and diseases.
7. Understand best management practices and determine appropriate SMZ width.

What is sustainable forestry?

Sustainable forestry means managing our forests to meet the needs of the present without compromising the ability of future generations to meet their own needs. It means practicing a land stewardship ethic which integrates the growing, nurturing and harvesting of trees for useful products with the conservation of soil, air, water quality, fish and wildlife habitat. The idea of sustainability means trying to do what nature does on her own--keep things in balance.

Humans have been part of this balance for thousands of years. It wasn't until the 20th century, however, that people had the machines and the population numbers to begin to throw things out of balance. We began taking away more than nature could grow back. We are trying to restore the balance by giving back to nature what we use. However, it is more than just a conservation issue, it is an economic issue as well. It makes sense for landowners to grow and use forests, harvest and replant. However, if it costs too much for them to grow and maintan the forests, landowners may sell the forests for things like housing developments and shopping centers. When this happens, the timber base is lost as well as wildlife habitat, carbon sinks, and other ecological benefits.

Biology does not respect political borders and sadly, vice versa. The principles of ecosystem management argue for a geographic scale based on ecological boundaries such as watersheds. However, we must respect the reality that political borders may be more significant to management than ecological boundaries in achieving sustainability.

The characterization of sustainable forest management is a challenging task from a scientific as well as national and international policy perspectives. Progress will be made step-by-step as countries gradually work within their own policies and opportunities to define the concept and measure the implementation of sustainable forest management. Many timber and trade organizations have adopted the goal of requiring all timber traded internationally to originate from sustainably managed sources. This is in response to the United Nations Conference on Environment and Development (UNCED), Chapter 11 of Agenda 21, and a host of other subsequent treaties and agreements. A "green" labeling or certification process to ensure forest products come

from sustainably managed forests has been developed. Four criteria integral to ecosystem management for sustainability are: maintenance of biological diversity, viability of ecological processes, productivity of soil, water and air and the ability to provide for sustained human use.

Criteria for sustainable development operates from the premise that individuals and communities achieve an optimum level of self-sufficiency and improved quality of life by using only renewable natural resources which fall within their political and natural boundaries. A sustainable community is one which provides all of its own needs for air, water, land, food, fiber, and energy resources within its own boundaries. Much study has been devoted to determining how much use or development is sustainable. There are many variables to consider and agreement must be reached on what is acceptable. Scientists and laymen do agree on the indicators that signal when we are achieving sustainability and when we are not.

Sustainable Indicators

Air One can live only two to three minutes without oxygen. Air quality is a critical indicator to human and planetary health. Considering the evidence of rising carbon dioxide levels, ozone depletion, and global warming, we can no longer presume that the air we breathe indoors and out is a renewable resource. Balancing the community's carbon dioxide to oxygen exchange is a critical indicator of a sustainable system.

Water One can live only two to three days without water. Humans require only approximately one to two gallons of water per day, yet we consume an average of 150 gallons per day for indoor and outdoor household use. Modeling the input and output of water resources of a site provide another challenging indicator for sustainability.

Land, food and fiber One can live only two to three weeks without food. Food and fibrous materials used for clothing, shelter, and paper are essential to sustenance and enjoyment. The three R's -- reduce, reuse, and recycle are useful concepts for sustainability. Total sustainable strategies would produce no need for disposal. Today's wastes become resources to be reused and/or recycled. Precycling to eliminate excess and non-recyclable packaging in products is important to reducing consumption. Buying products made from recycled content is also critical.

Energy Energy is the primary change agent in ecological systems. Sustainability can be modeled by a site or society's percentage use of renewable versus non-renewable energy resources. Full sustainability would require a site or society to completely shift to renewable energy systems.

Human ecology Humans define the final and most inclusive indicator. The degree of commitment and action programs toward a sustainable future is critical in modeling this variable. Humans can determine the existing use of each resource, the non-renewable and renewable supply of each of the resources on a "site" and the estimated percent of conservation required to place each human influenced environmental system in balance.

New technology will be able to help as communities, agencies and organizations recognize

how collective actions affect each other and partner to solve problems. Technology allows research and alternatives to be modeled to see how well they work and how they interact before large investments are made.

Technology in Forestry

Humans use the forest for many purposes, including recreation and providing drinking water, habitat for wildlife, and timber for wood and paper products. To maintain these benefits it is important to evaluate all possible effects of forest management activities on the ecosystem. Forest management requires roads and trail systems to provide access for all uses. It also requires choosing a way to grow future forests. Computers and satellite technology help forest managers make decisions which meet human needs without harming the ecosystem. Computer applications are used to model the effects of different management activities. Computers even help determine the economic value of standing timber.

In order for foresters to estimate the value of standing timber, measurements of sample plots must be taken throughout the forest. This is called "timber cruising". Every tree within the plot is measured, either by hand or estimated with the eye. It takes years of practice to accurately measure trees with your eyes. After trees within a plot are measured, then they are multiplied by the number of acres being inventoried. This creates a "blow-up" effect, which allows you to get an idea of what's there without actually measuring each and every tree in the forest. Naturally, the larger the plots and the more measurements you take, the better your estimate and the true value of the timber.

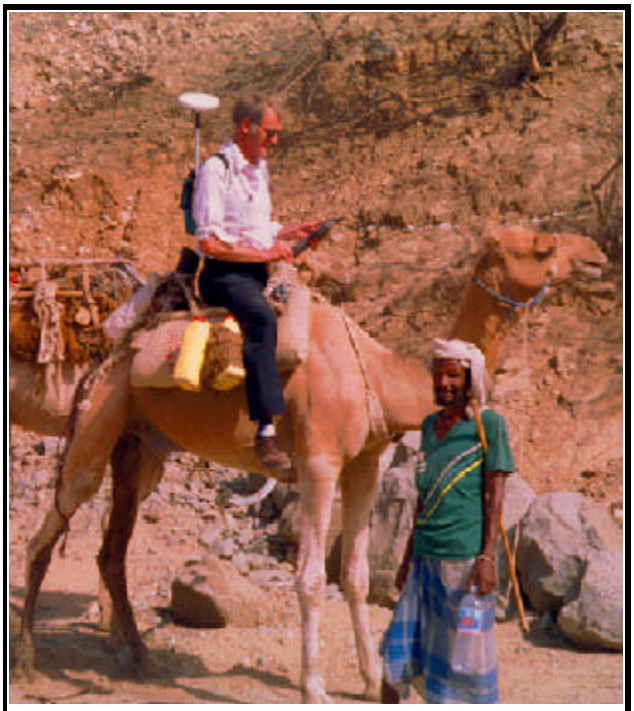
Global Positioning Systems

Global Positioning Systems (GPS) are space-based radio positioning systems that provide 24-hour, three-dimensional position, velocity and time information to suitably equipped users anywhere on or near the surface of the Earth (and sometimes off the earth). Global Navigation Satellite Systems (GNSS) are extended GPS systems, providing users with sufficient accuracy and integrity information to be usable for critical navigation applications. The NAVSTAR system, operated by the U.S. Department of Defense, is the first GPS system widely available to civilian users. The Russian GPS system, GLONASS, is similar in operation and may prove complimentary to the NAVSTAR system.

These systems promise radical improvements to many systems that impact all people. By combining GPS with current and future computer mapping techniques, we will be better able to identify and manage our natural resources. Intelligent vehicle location and navigation systems will let us avoid congested freeways and find more efficient routes to our destinations, saving millions of dollars in gasoline and tons of air pollution. Travel aboard ships and aircraft will be safer in all weather conditions. Businesses with large amounts of outside plants (railroads, utilities) will be able to manage their resources more efficiently, reducing consumer costs.

Geographic Information Systems

Upon collecting data in the field with a GPS receiver, the forester or other resource manager, attaches a cable to the device and downloads the information to the computer. The computer mapping system then interprets the data and plots it on a statewide map, topography map, or other device. This allows the user to calculate acreages, timber types, cultural resources, endangered species, streams and rivers, etc. and see how the data is distributed across an area. This information most often is in the form of digital overlays so each data set can be studied separately, or viewed as a whole.



GPS and GIS are being used all over the world

The most valuable aspect of GIS is that it helps managers make more informed decisions. For example, a certain endangered species may need a 500-yard undisturbed radius around its nest and the forester wants to plan the best possible route for a logging road through the area without disturbing the animals. The forester collects GPS data on nest locations and where the road needs to begin and end. GIS plans the route within the constraints that the user sets. This saves hours of work and money by optimizing all resources.

Economic and Eco-nomic value of forests

The economic value of forestry to Georgia is tremendous. The Georgia forest industry directly and indirectly employs over 100,000 people. Timber is the highest valued crop produced in Georgia. The forest industry also creates value-added to the forest economy and primary manufacturing industries. Georgia has the largest recycled paper manufacturing industry in the southeastern United States. Recycling paper adds value to the trees as it extends the amount of products derived from trees. Second and third tier manufacturers dependent upon the forest industry are also located in Georgia. These include furniture manufacturers, mobile home plants, box, and bag plants, computer paper makers, diaper, toilet paper, napkin and many other manufacturers supplying products for final use by consumers and businesses. There are literally over 5,000 products that come from trees that we use every day. Some are obvious, but others such as the list on page 6 are not so easily recognizable.

The intangible benefits Georgia's forests provide that contribute to the quality of life are also often overlooked. The forests help clean the air, and water, buffer noise, provide recreational

benefits, wildlife habitat, and serve as a carbon sink by fixing carbon dioxide from the atmosphere. It is difficult to calculate these values in terms of dollars and cents. Consider the following:

An acre of trees can store 2.6 tons of carbon each year. This can compensate for automobile fuel use equivalent to driving a car between 7,200 and 8,700 miles.

An acre of trees can remove between 287 and 651 tons of sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone and particulate matter per year. Pollution removal varies based on weather, canopy cover, length of growing season and pollution concentration.

An acre of trees will provide about 2.8 tons of oxygen per year. This is enough for 14 people.

Tree cover over pervious surfaces can reduce runoff as much as 40% and reduce the costs of treating stormwater runoff by decreasing the volume of water handled during periods of peak rain events.

Energy use in a house with trees can be 20 to 25% lower per year than that for the same house in an open area.

Wide belts of (30 m) of tall dense trees combined with soft ground surfaces can reduce noise by 50% (6 to 10 decibels).

Trees provide wildlife habitat. Wildlife can serve as biological indicators of changes in the health of the environment.

Aesthetic values such as the beautiful colors of fall displayed in the north Georgia mountains brings thousands of tourists to the area each year. These visitors spend millions of dollars while enjoying the recreational opportunities. Without this draw, many businesses would not survive in this area of the State.

Economic development based on degrading the natural resources cannot be sustained. Neither can environmental protection be ensured unless people's basic needs and wants are first satisfied. The villian is not economic activity but economic scarcity. There are just not enough productive resources including people, capital, and natural resources to produce all the products such as cars, medical care and the ecological quality we want. Careful management, however goes a long way toward providing most of these needs and wants including environmental quality.

Georgia’s forests are important for jobs, production of goods we need and use every day, and to protect the health of the environment and ourselves. Conservation of these resources through both forest management and individual stewardship is essential.

Sustained Yield

Is it possible to preserve forests and cut them down at the same time? If they are carefully managed at a sustainable rate of harvest, the cycle of harvesting, replanting and growth can go on forever without running out of trees. For years, foresters have practiced the principal of sustained yield. Sustained yield is the rate at which a resource may be used without reducing its long-term availability or limiting its ability to renew itself.

For example, there is a Christmas tree farm made up of four different areas. The trees in each area are five years older than the trees in the area next to it. The trees in plot A have just been planted, the trees in plot B are 5 years old, the trees in plot C are 10 years old and the trees in plot D are 15 years old. The Christmas trees in plot D are mature and ready to be harvested for the holiday season. No others are harvested. Once plot D is harvested, seedlings are replanted. A harvest of each plot can be done every 5 years without running out of trees.

Another example is to assume this Christmas tree farm contains 4,000 trees and each year you want to cut 20 percent of them (800 trees) and replant 1,000 trees each year. Will the Christmas tree forest eventually disappear? Will it stabilize? If so, in how many years and with how many tees?

Answers: The forest will not disappear given stable soil, water, climate, and biological conditions. Planting back 1,000 trees increases the forest by 200 trees per year. The entire forest will be cut over once in 5 years with a harvest rate of 20 percent per year. But since 1,000 trees are being replanted each year, at the end of 5 years you will have a gain of 1,000 trees.

The forest will stabilize after 5 years at 5,000 trees and will have a balance of age classes or an equal number of trees in each age class. The long term sustained yield capacity will also have been reached in 5 years assuming the growth rate cannot be changed by changing species, genetic selection for more rapid growth, fertilization or thinning.

The same principles are applied to tree farms for forest product production. It is similar to planting and harvesting a garden. The key is to control the rate of harvest to insure a continuous supply for present and future generations.

Sustainability Case Study

John inherits a 1200-acre farm in the Georgia Piedmont. Farm records show the land uses are:

120 acres of grass for pasture or hay
50 acres of cultivated row crop land
20 acres of water in three ponds
10 acres with the farmhouse, garden, orchard and barns
1,000 acres forested

Of the 1,000 acres, 60 percent (600 acres) are loblolly pines forest type, 35 percent (350 acres)

are oak-hickory forest type, and 5 percent (50 acres) are bottomland hardwoods along a major creek at the back of the farm.

John wants to keep the farm in the family, make an annual income great enough to pay the taxes and routine maintenance and use the farm as a family retreat. Taxes are $8,000 per year, and handyman/yard service $100 per month so John will need $9,200 annual income from the farm to take care of these expenses. Potential income could be:

120 acres hay field @$15 per acre	$1,800
50 acres of renting row crops @$30/acre	1,500
1,200 acres hunting club lease @$5/acre	6,000
Total	$9,300

This could meet John's need for expenses, but John does not want to lease the forested land to a hunting club. He wants the wildlife there to be relatively unafraid of humans and doesn't want to worry about timing visits to avoid seasons or hunters. He wants a safe play environment for his children, good wildlife habitat for medium to high populations and diversity of wildlife including non-game, clean water in the ponds and creek, undistubed forest along the creek which is a special place for him because of his memories of fishing there with his grandfather, and a forest that is healthy so that insects or disease do not threaten his other goals. He also wants a scenic forested area for hiking, picnicking, bike riding, wildlife watching, photography and other recreational activities.

John consulted a forester. The forester inventoried the kinds of trees, their ages, how many stems there are per acre, their growth rates, their quality, and how well suited they are to the ecological conditions of the land on which they are growing. A map is made of the forest types that are alike and the information summarized as follows:

Age Class	Acres of Pine	Acres of Hardwood
0 - 10	90	0
11 - 40	300	105
41 - 80	180	260
80+	30	35
Total	600	400

The forester also found that the 35 acres of hardwood in the over 80 age group are bottomland hardwoods along the creek. The remaining 15 acres of bottomland hardwood are also along the creek but are in the 41-80 year age class. Most of the 90 acres of 0-10 year old pine type is the result of a Southern pine beetle outbreak which killed the older pine on these areas. These 90 acres were salvage harvested by local loggers. John's grandfather had reforested these areas and they had young, fast-growing loblolly on them.

Based on the knowledge of timber markets, local wood industry and tree growth the following recommendations were made:

1. No harvest in the 35 acres of 80+ year old bottomland hardwood to meet John's goal of preserving it as a special place.

2. Thin the entire 11-40 year age class, both pine and hardwood with the first harvest in the current year. Favor the best trees to grow for the future. In the hardwoods, favor the nut-bearing oaks and hickories as the trees to be left and protect existing den trees from cutting or logging damage to meet wildlife habitat goals. The estimated income for both pine and hardwood thinning is $70 per acre. This harvesting should be spread over 7 years by thinning 100 acres every other year. This thinning provides needed current income, provides for future increased revenue, reduces risk of insect attack and provides wildlife habitat. (Income: $7,070 for each thinning)

3. Harvest 20 acres of pine 80 years old or older every 5 years by the seedtree method leaving 8 to 10 trees to reseed the area and start a new forest. After the first seedtree harvest in the current year, seedtrees would be removed every 5 years as a new seedtree cut is made. These harvests remove the trees most likely to be killed by the Southern pine beetle, minimizes reforestation costs and provides a steady supply of shrub-weed type habitat for wildlife. Gross income for the first cut should be about $750 per acre and $200/acre five years later at seedtree removal. This amount of harvest should be maintained on the same schedule indefinitely. (Income: $15,000 first year, and $4,000 for each seedtree removal cut.)

4. Defer any harvest in the 41-80 year old hardwoods for at least 10 years or until objectives change, then re-evaluate.

5. Keep 10 acres of 80+ year old pine which is around one of the ponds as a family recreation area unless it is attacked by beetles, in which case a clearcut and conversion to oak-pine type could be made through planting pines at wide spacing and allowing stump sprout regeneration of oak and hickory.

6. Buffer the large creek during thinning harvest with a 100 foot no harvest zone. Buffer all other streams with a 50-foot wide no harvest zone on each side of the stream to filter runoff from upslope.

7. Require the logger to reseed log landings and skid trails with grass and legume seed mix for wildlife and to prevent soil erosion. Re-evaluate management plan, objectives and results every 5 years and adjust as necessary due to changed conditions.

The recommendation to seedtree harvest 20 acres of 80 year old pine every 5 years is sustainable since only 40 acres will be harvested every 10 years and each age class has at least 45 acres. Then a "new" set of acres will age into the 80-year old class in time for the next scheduled harvest. John's income will be periodic rather than annual. Once the thinnings end, income will come in only every 5 years, so John will have to save and budget for expenses that occur during the years he has no revenue from forestry.

What are the diseases and insects affecting Georgia's forests?

There are hundreds of diseases and insects that kill and damage Georgia's hardwoods and pine forests each year. Several will be described here.

Southern pine beetle - This insect is of utmost concern to foresters, landscapers, recreation managers, and homeowners. It wipes out acres of southern pines when conditions are favorable. These beetles occur not only in Georgia but throughout the south and even Central America. Adult beetles are about the size of a grain of rice, and reddish-brown in color. They bore directly through the bark, mate, and the females begin to excavate S-shaped egg galleries in the inner bark. The eggs hatch into legless grubs within four to nine days. The grubs mine for a short distance and pupate in the outer bark. There are from three to seven generations per year depending on locality and weather. Drought seems to be associated with major outbreaks of the southern pine beetle. Control includes rapid salvage of infested trees where possible. Felling trees in a circular plot toward the center seems to disorient the beetle so it starves before it can reach healthy trees. Piling and burning of infested material also seems to help diminish beetle outbreaks.

Bagworms - These wingless, maggot-like adult female bagworms are present in September and October and spend their entire lives in the silken bag they construct as larvae. Males fly around infested shrubs in the fall searching for a mate. Mating takes place through the open end of the bag. The female then deposits an egg mass of up to 1,000 eggs in her pupal case. They begin hatching in April and defoliate conifers and even many hardwoods including wild cherry, poplars, oaks and apple trees. Cold temperatures reduce their numbers. Homeowners can control by handpicking bags and destroying them.

Gypsy moth - The gypsy moth was brought to this country from Europe in 1869 and has spread from the northeastern United States to the north Georgia mountains. It defoliates both hardwoods and conifers. Full grown caterpillars measure more than two inches long and are identified by five pairs of blue spots and six pairs of red spots in a double row along the back. Adult moths are active from June to September and the females rely on sex attractants to lure male moths. Thousands of dollars have been spent on methods to control this insect including fake sex attractants and introduced parasitic predators. The greatest problem in controlling the insect is the fact that recreational vehicles transport egg masses and larvae from infested to uninfested areas.

Ips engraver beetle - With the exception of the southern pine beetle, no other insects cause as much mortality to the southern pine forests as the Ips engravers. They usually attack weakened trees, lightning-struck trees or fresh slash left by logging operations. During droughts they can successfully attack healthy pines. The Ips quickly girdle the tree as they build their egg galleries in the inner bark. Death is usually hastened by the introduction of blue-stain fungi which blocks the flow of sap. Small reddish pitch tubes are one of the first signs of attack. Peeling back the bark will reveal the typical Y-or H -shaped egg galleries with short larval galleries extending perpendicular to them on either side. Ips beetles have "scooped out" posteriors surrounded by varying numbers of tooth-like projections.

Fusiform rust - Fusiform rust is one of the most important diseases of southern pines. It is recognized by the spindle-shaped canker on the pine branches or main stem. In early spring, these swellings appear yellow to orange as the fungus produces powdery spores. As the host tissue is killed, older stem cankers become flat or sunken. Cankers often girdle trees. Fungus spores from the pine infect oak leaves. Brown hair-like structures produced on the underside of oak leaves in late spring, reinfect the pine trees completing a “rust” cycle. Cutting out seedlings with galls will reduce the incidence in new plantations. Pruning infected branches will prevent stem infection in young plantations.

Red heart - Red heart disease occurs in mature conifers. The fungus attacks all species of mature pines in the south. Infection occurs through dead branch stubs. Advanced stages of heartrot appears as elongated white pockets or flecks, formed parallel to the grain and separated by firm wood. Control is achieved by pruning dead and dying branches flush with the main stem to allow the knot to be quickly overgrown by sapwood thus preventing the fungus from entering through the branch stub.

Dogwood anthracnose - Dogwood anthracnose causes leaf spots, stem cankers, and kills shoots of infected trees. Initial symptoms are purple-bordered leaf spots, scorched tan blotches that may enlarge to kill the entire leaf. Trunk sprouts occur during the later stages of disease development. Prune dead wood in the tree before disease reaches the main trunk. Destroy the pruned wood to eliminate infection. Dogwoods adjacent to natural stands of the species may be more susceptible.

Chestnut blight - Chestnut blight is caused by the Endothia parasitica fungus. It was introduced when the Chinese chestnut was imported to this country in the early l920's. The fungus wiped out the American Chestnut in Georgia and throughout the mountains. The fungus survives in previously killed stumps and later kills the new sprout growth. The chestnut blight fungus is also parasitic on chinkapin, spanish chestnut and post oak. Japanese and Chinese chestnuts are resistant.

Pesticide Use in Forestry

Pesticide use in forestry can be controversial. However, pesticides have enabled us to increase crop yields including timber on an ever shrinking land base to meet the demands of a growing population. The three primary groups of forest pesticides are herbicides (which kill plants), insecticides (which kill insects) and fungicides (which kill fungi).

Purpose of pesticide use in forestry

1. To protect forest visitors (fire ants, poison ivy)
2. To protect trees, tree seeds, and wood products from damaging insects and diseases especially in nurseries
3. To prepare land for planting or seeding by removing competition for space, water, and nutrients
4. To maintain survival and growth of those trees which best meet management objectives

Herbicides

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Herbicides are the most widely used category of pesticides for forestry. Georgia and the southeast are well-suited for the commercial production of pines used for lumber and paper. When herbicides are used here, it is usually for site preparation before planting pines and to prevent hardwoods from taking over the site once pines are established.

Another management objective may be to preserve habitat for wildlife and endangered species. For example, the endangered red-cockaded woodpecker favors live loblolly and longleaf pines infected with red-heart disease to nest. Encroachment of hardwoods brings predators and causes the woodpeckers to abandon the site. Herbicides are sometimes used to preserve the park-like stand for these woodpeckers.

Pesticides used on the National Forest are applied so they do not harm wildlife such as deer, squirrels, bear, fish, etc. The target species for herbicides are usually 5-7 year old hardwoods on a site managed for high quality pines. These hardwoods are not part of wildlife diets when the hardwoods have reached that size. Once the competing hardwoods die, forbes such as broadleaf weeds, wildflowers and berries grow in their place, increasing the food supply for a greater diversity of wildlife and beneficial insects.

Insecticides

Insecticides are not widely used in forestry due to the large areas of application needed to control the insects. The cost and environmental concerns associated limit these applications. One exception is aerial spraying for gypsy moths in north Georgia with Bacillus thuringinsis (Bt). Bt is a naturally occurring soil bacterium which is specific for certain species of caterpillars.

Fungicides

Fungicide use in forestry is mainly limited to single stem applications for high value trees. The life cycles of fungi coupled with their ability to generate large amounts of spores can make their control almost impossible. Fortunately, with the exception of the chestnut blight our forests have not been hit with major losses from fungi.

Methods of Application

There are two main categories of applying pesticides in forestry:

1. Broadcast methods such as aerial or ground spray units cover larger sites and are generally quick and cost effective.

2. Selective methods such as basal soil treatments (also known as spotgun or grid), thinline, injection, cut surface and backpack directed sprays are also commonly used in the south-east. Selective methods use less herbicides and place it only where needed. It is more flexible by combining methods and controlling only the species treated. Selective methods are considered more environmentally sensitive and are the only methods of herbicide application used on the National Forest. One disadvantage is that selective methods are labor intensive which can make them expensive.

Regulations and Safeguards

It is illegal to apply a pesticide in a manner inconsistent with its label. A label is more than the sticker on the package. It is the document which contains the information needed to correctly apply a pesticide. It is important to note that the rates listed on a label may not be exceeded but may be reduced. In many areas such as the National Forest, pesticides are used at the lowest effective rates, applied selectively or combined with integrated pest management (IPM). For example, where herbicides might be applied on the National Forest to control hardwood competition, only 20%-30% of the stems would be treated. Plants or animals of special concern, water and adjacent woods are buffered with untreated areas.

In addition to the pesticide label, the Material Safety Data Sheet, (MSDS) is a very important document. The MSDS should be available to anyone handling a pesticide. It contains information on health hazards, first aid, disposal, ingredients and physical data.

In Georgia, to apply pesticides you must have a pesticide applicators license to purchase and apply restricted use pesticides. When applying forest pesticides for hire, you must have a Commercial Pesticide Contractors License, Category 23 and a Pesticide Contractor's License.

Integrated Pest Management

Reliance on chemical pesticides in forestry has declined in some areas due to an integrated pest management approach (IPM). IPM uses biological control, prescribed burning, various silvicultural methods, and salvage harvesting as alternative ways to control pests. Integrated pest management assumes a certain level of pests is tolerable and can combine control techniques including chemicals to achieve successful results. When chemical pesticides are used, they are applied when the pests are the most vulnerable. This decreases the volume of chemicals needed and helps preserve diversity of the ecosystem. An example of IPM is prescribed burning to control brown spot needle blight (a fungus) on longleaf pine and salvage cutting of southern pine beetle infested trees. Pines infested with the beetle and a buffer of "green" pines are felled toward a center point. This disorients the beetles and they starve before they can be carried by the wind or crawl to another stand. If the trees are cut soon after the infestation begins (3-6 months), they can be salvaged for pulpwood. If not, the trees should be burned in a prescribed burn to kill larvae and prevent further spread of the insects.

Another example of IPM is biological control such as releasing sterile insects into an outbreak of pests or increasing the habitat for or attracting the natural enemy of the pest. Research continues in IPM to reduce the use of pesticides, especially insecticides. Recent studies have discovered a natural repellent, 4-Allyanisole (4aa), in the resin of pines. The development of compounds like 4-aa hold great promise for the further reduction of pesticide use in the future.

Integrated pest management seeks to work with nature to control pests. It offers the best alternatives for preserving our natural resources and sustaining the ecosystems that support us.

Best Management Practices

The Federal Water Pollution Control Act of 1972 requires states to develop a program to protect and improve the physical, chemical, and biological integrity of the nation's waters so that they remain fishable and swimmable for every generation. Best Management Practices (BMPs) are guidelines to protect soil and water quality during ground disturbing activities such as forestry, agriculture, construction, and industrial operations. Each of these activities has their own set of BMP guidelines. The practices addressed here pertain to forestry and related silvicultural actions such as road building, stream crossings, timber harvesting, site preparation, reforestation, prescribed burning, fire suppression, fertilization, revegetation and stabilization of sites.

Many elements of BMPs have been incorporated into federal, state and local laws and regulations. Violations of these critical protective measures can result in prosecution and substantial fines. An example of a violation would be an activity that raises water temperature more than five degrees Fahrenheit which impacts fish habitat.

BMPs apply to state waters. According to Georgia law, waters of the state include all rivers, streams, branches, creeks, lakes reservoirs, ponds, drainage systems, springs, wells, and other bodies of surface or subsurface water (natural or artificial) within or forming boundaries of Georgia. Waters that are entirely confined and retained completely upon the property of an individual partnership or corporation are not state waters.

Water quality protection begins with planning. The first step is identifying watercourses and water bodies such as perennial and intermittent streams, wetlands, sloughs or natural ponds. Stream type is important in determining the level of protection that should be implemented. Topographic maps and county soil maps can help identify stream types, but where available, should be cross-referenced and field verified.

Stream Types

Perennial streams flow in a well-defined channel most of the year under normal climatic conditions. Some may dry up during drought periods due to excessive upstream uses. Aquatic organisms are normally present and easily found in these streams.

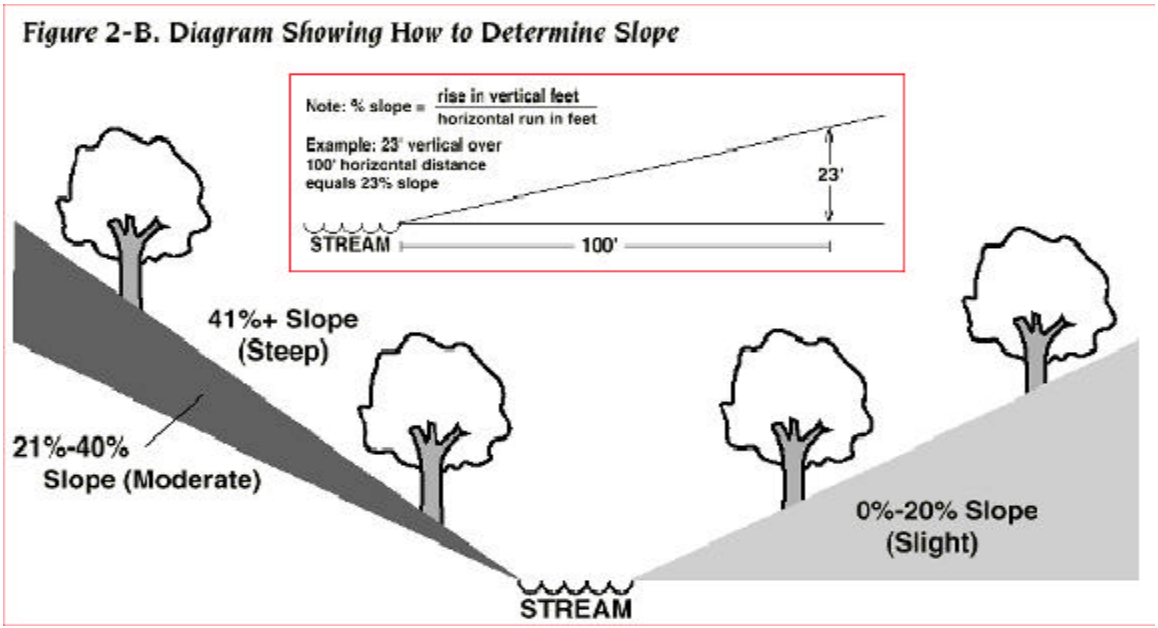
Intermittent streams flow in a well-defined channel during wet seasons of the year but not for the entire year. Water velocity is sufficient to move soil material and aquatic life is difficult to find or not present in these streams. Topographic maps identify intermittent streams with blue lines separated by three dots. County soil maps identify them with black lines separated by two or more dots.

Ephemeral areas have water flows only after rainstorms. They are often referred to as drains, draws or dry washes and have no well-defined channel but do flow into perennial and intermittent streams. They are not usually identified on maps and do not support aquatic life.

Streamside Management Zones (SMZs)

Streamside Management Zones are buffer strips next to perennial and intermittent streams and other bodies of water to be managed with special considerations with the goal of protecting water quality. These considerations include cover to shade and buffer water temperatures, natural filtration of sediment and pollutants, travel corridors for wildlife, flood protection, and woody debris vital to the aquatic ecosystem. There is no uniform formula to determine the appropriate width of a Streamside Management Zone. In general, however, the steeper the slope and more erosive the soil, the wider the SMZ.

Slope steepness should be determined from a point 100 feet perpendicular to the streambank. Therefore, SMZ widths may vary along a stream's course and on opposite sides of the stream. SMZs should be measured along the ground from the stream bank on each side of the stream and not from the centerline of the stream. After you determine percent of slope, check the chart by slope class and stream type to determine the width of the SMZ.



SMZ Widths by Slope Class and Stream Type

Slope Class	**Minimum Width (ft) of SMZ on Each Side**		
	Perennial (feet)	***Intermittent (feet)***	***Trout (feet)***
Slight (less than 20%)	40	20	100
Moderate (21-40%)	70	35	100
Steep (greater than 40%)	100	50	100

BMPs for Perennial and Intermittent Streams

Management activities may occur within an SMZ provided the disturbance to ground cover and the soil is minimized, water quality objectives are met, potential pollutants from the SMZ do not move into the watercourse and stream bank integrity is protected. These guidelines include:

- Adhering to local, state or federal regulations
- Determining and designating the appopriate SMZ width before conducting forestry practices
- Minimizing stream crossings
- Locating log decks, staging areas and skid trails outside the SMZ on well-drained, stable soils
- Installing firebreaks outside SMZs
- Minimizing intensity of prescribed fire in the SMZ to maintain forest floor cover
- Leaving at least 50% canopy cover along perennial streams after a harvest or an average of 50 square feet of basal area per acre evenly distributed throughout the SMZ to provide shade (Basal area is the cross sectional area of a tree stem at breast height, including bark expressed in square feet per acre.)
- Leaving at least 25% canopy cover along intermittent streams after a harvest or an average of 25 square feet of basal area per acre evenly distributed to provide shade
- Inspecting the SMZ periodically to evaluate the effectiveness of the BMPs and adjust practices when necessary

Practices to avoid within SMZs for perennial and intermittent streams

- Cutting stream bank trees
- Unnecessary access roads and main skid trails
- Portable sawmills
- Soil compaction
- Removing ground cover or understory vegetation
- Mechanical site preparation or mechanical tree planting
- Felling trees into streambed or leaving logging debris in stream
- Servicing or refueling equipment
- Burning for site preparation
- Handling, mixing, or storing toxic or hazardous materials (fuels, lubricants, solvents, pesticides or fertilizers)
- Broadcast application of pesticides or fetilizers

Some areas are considered sensitive and require more stringent protective measures. These include, but are not limited to, mountain trout streams, protected river corridors, water supply reservoirs/watersheds, ditches, canals, sloughs, wetlands braided streams, gullied areas and protected mountain tops. For trout streams, establish a 100-foot SMZ on both sides of the stream and its tributaries that includes one of the following choices:

Option A: A no-harvest zone within the first 25 feet of primary or secondary trout streams. Timber harvest in remaining 75 feet should leave 50 square feet of basal area per acre or 50% canopy cover.

Option B: Leave 50 square feet of basal area per acre evenly distributed throughout the 100-foot zone. This option can only be used if a qualified professional is consulted.

Most other sensitive areas are treated as perennial streams. Consult the *Georgia's Best Management Practices for Forestry* publication available through Georgia Forestry Commission or a qualified professional for further guidance.

Any forest management activity, regardless of potential impact on water quality should be thoroughly planned. Plans need to consider:

1. the history and past use of the land
2. sensitive areas
3. location, type, timing and logistics of each forestry activity
4. regulations or requirements superseding BMPs

The planning process helps to identify applicable BMPs, minimize enironmental impacts, reduce costs, and preserve the long-term productivity of the land.

Urban Forestry

Objectives

1. Define urban forestry.
2. Describe challenges to trees in an urban environment.
3. Determine tree species appropriate in an urban environment.
4. Know how to assess the health of an urban ecosystem.
5. Describe patterns of urban growth.
6. Identify ways to protect trees during construction.

What is urban forestry?

Urban forestry is the planting, care and management of trees and tree benefits in a community. The urban forest is an ecosystem of all the trees, wildlife, associated vegetation and other natural resources along a street, in open green spaces, parks, commercial and private properties in a city, town or community. People influence the health of the urban forest more than any other ecosystem.

Growing large trees (trees with a 20-foot crown spread) in most urban areas is difficult because soil conditions are usually poor, there is limited growing space, urban temperatures are elevated, pollution is usually greater and trees in the city receive more physical abuse. Damage to trunks from lawn mowers, cars, and people carving their initials causes wounds which opens the way for insect and disease attacks. Overhead wires and underground utility pipes restrict growing space. The compaction of the surface soil, air and soil pollutants, road salt and exposure to harsh wind and heat reflected from concrete are additional problems. Trees under stress can also become hazards if not properly maintained. The average tree in the city lives 32 years but a tree in the downtown area may live only 7 to 10 years. The same tree on a rural site might live 200 years in the absense of development stress.

An additional challenge affecting the health of trees we are increasingly concerned about is ozone. While the earth needs a protective layer of ozone in the stratosphere to block harmful solar radiation, in the lower atmosphere it is a serious pollutant. Ozone is formed in the air by a reaction of hydrocarbons and nitrogen oxides with sunlight. These chemicals are released into the atmosphere primarily by the burning of fossil fuels for transportation or power generation. Ozone is the most widespread air pollutant in the United States.

Ozone is a gaseous molecule having three oxygen atoms as opposed to the normal state of oxygen consisting of two oxygen atoms. It has a distinct odor and is found in small amounts when ordinary oxygen is struck by lightning. It can be made in laboratories with electricity. Ozone is highly reactive and because of its unstable state, the molecule splits easily into ordinary oxygen and an extra oxygen atom. This lonely oxygen atom quickly oxidizes whatever comes across it; therefore ozone is a strong oxidant useful in purifying water and harmful impurities. The problem with ozone is that when it comes into contact with living matter whether it is a plant

leaf or a human lung, it reacts violently, causing cell damage. Ozone inhibits photosynthesis and plant growth.

Volatile organic compounds (VOCs) and nitrogen oxides that form ozone come from both natural and human activities. Isoprene, which is the largest of the VOC's from natural sources is highly reactive and one of the most effective in producing ozone. At room temperature, trees emit VOC's; one of which is isoprene. Natural VOC emissions increase with higher temperatures and intense sunlight. Trees in urban areas can reduce the urban heat island effect which decreases the acceleration of VOC emissions. Trees planted directly around structures can reduce air conditioning needs which in turn, reduces the amount of VOC's released at power plants.

Deciduous trees have higher emissions than evergreens but large evergreen forests can have significant emissions. Sweetgum, oak and poplar trees native to Georgia emit high levels of isoprenes. Other species such as magnolia, pine, ginkgo, maple, hickory, dogwood, alder, beech, sourwood, birch, holly, mulberry, redbud, cherry, sassafras, and elm are low emitters and should be seriously considered as replacement trees and trees to be protected during construction in urban areas if you are managing for air quality benefits.

Because of these natural emissions, some ozone is present even in the absence of human activities. Scientists estimate than an average natural ozone concentration is 25 to 45 parts per billion. This is much lower than the current ozone standard of 125 parts per billion. Thus, natural emissions by themselves would not cause unhealthy ozone levels. The main contributors to high ozone levels is from the burning of fossil fuels for transportation or power generation.

What trees are appropriate for urban settings?

Trees enhance the beauty and value of a home, street, and a city. However, planting a tree in the wrong place can cause property damage and become a detriment rather than an asset. A few minutes carefully planning the type of tree to plant and where to plant can save thousands of dollars in the long term.

When selecting the tree, there are several questions you should answer.

1. First, determine why the tree is being planted. Do you want the tree as shade, screening, spring flowers, fall color, to frame your house or landscape, to help manage stormwater runoff, or simply something green?
2. How large will the tree ultimately become? Will it still fit into your yard or streetscape when it is mature? Will the tree form an upright, round or spreading type crown? A dangerous traffic situation is created when tree limbs screen traffic lights, street signs or your own driveway. Trees often cause electrical problems either by limbs rubbing on wires or large limbs falling on lines. A tree planted too close to a sidewalk, driveway or house foundation can lift and break a large amount of paving. A minimum of 6 feet from curb to sidewalk is recommended for small trees. A shallow-rooted tree will often clog sewer lines. Remember the root system of a tree needs as much area as the above ground portion occupies in the air.

3. Will the tree bear objectionable fruit or produce seeds that will litter the ground?
4. Will the tree be able to survive the local climate and pollution conditions? Is the wood strong enough to bear loads of ice and wind without breakage?
5. Will the tree fit with your architectural plans, and how will it affect your neighbor's property?
6. Is the tree a low emitter of volatile organic compounds (VOC's) if ozone is a concern in the community?
7. Is the tree native to the area? Native trees usually require less maintenance and are more likely to thrive.

Recommended Small Trees (15 to 25 feet tall at maturity, these trees may be planted near electric lines)

Flowering Dogwood (Cornus florida)*
Eastern Redbud (Cercis canadensis)*
Flowering Crabapples (Malus species)
Crape Myrtle (Lagerstroemia)*

Recommended Medium Sized Trees (25 to 50 feet tall at maturity. Do NOT plant within 30 feet of electric lines)

Carolina Cherry Laurel (Prunus caroliniana)*
Japanese Maple (Acer palmatum)*
Sourwood (Oxydendrum arboreum)*
American Holly (Ilex opaca)*

Recommended Large Sized Trees (50 feet or more at maturity. Do NOT plant within 50 feet of electric lines)

Southern Magnolia (Magnolia grandiflora)*
Pin Oak (Quercus palustris)
Live Oak (Quercus virginiana)
Ginkgo (Ginkgo biloba)* *Plant only the male tree as the fruit of the female gives off an objectionable odor and fruit*

*Low emitters of VOC's

How do you assess the health of an urban forest ecosystem?

The tree cover, or tree canopy, in a community is the central measurement most often used to determine the condition of urban forests. The health of an urban ecosystem is much more complicated than the number of trees it has, but the tree cover is a good indicator because the health of the trees and the ecology of the area are directly related.

Tree canopy goals have been established for three zones within a metropolitan area. The three zones and recommended minimum canopy goals are:

Business Districts	15%
Urban Residential	25%
Suburban	50%

A community should strive to reach these canopy goals by zone. Because each community is different, zones will be of varying sizes. The goal is to achieve an overall coverage of 40 percent.

One of the reasons for tree cover is to mitigate the heat island effect. Today's cities are "hot spots" on the landscape with average temperatures three to 10 degrees higher than the surrounding countryside. By transpiring water, altering windspeeds, shading surfaces, and modifying the storage and exchanges of heat among urban surfaces, trees affect local climate, and thereby influence thermal comfort and air quality.

Another reason for tree cover is energy conservation. Research has shown that the shade from three trees properly planted around a home can cut air conditioning costs by 20% or more. Tree arrangements that save energy provide shade primarily on east and west walls and roofs, and wind protection from the direcction of prevailing winter winds. This reduces the amount of fossil fuel that must be burned. The burning of fossil fuel is the primary source of atmospheric carbon dioxide.

Trees are also important to stormwater management. Tree canopy reduces the velocity of falling rain, helps stormwater infiltrate into the soil, settles particulates, slows runoff and prevents erosion. Trees used as buffer zones along streams and high runoff areas such as streets, and parking lots, help protect water quality.

As cities grow, forests are usually cleared, the land graded, and paved. As a consequence, the number of trees that once grew there and the life processes supported by those forests are replaced by man-made ecosystems. The cutting of trees done for urban development differs from when trees are cut in a managed forest in htat in a managed forest, the cut area is reforested so there will be a continuous supply of timber and the forest ecosystem preserved. In order to provide for human needs and a strong economy, we must have growth. The key is learning to manage growth.

Managing Growth

Georgia has witnessed unprecedented growth the past three decades. The rapid pace of development has turned many farms and forests into super highways, housing and industrial developments, strip malls and mega-shopping centers. At the same time, this development has contributed to the decline of older cities, towns and suburbs. Some communities have responded with no growth or slow growth policies. These policies tend to scatter development which increases the vehicle miles driven, and traffic congestion by forcing people who work in the city to

find housing elsewhere. As cities grow at the urban fringe, the inner city infrastructure is abandoned while new infrastructure is built to support the peripheral growth areas. As cities struggle to pay for these investments and their maintenance, support for necessary services declines. The lesson learned from this is to accommodate growth in ways that make sense, preserve the community, protect the environment and enhance the economy. This is known as "Smart Growth".

Smart growth changes the urban sprawl pattern of development to development that enhances existing communities, is compatible with the natural environment, uses tax dollars efficiently, and is profitable for private investment. Smart growth includes conserving natural resources, open space and sustainable habitats. Examples include using wetland systems to purify stormwater runoff before it discharges into a lake or leaving as many trees as absolutely possible in a development that can reasonably be expected to survive.

Leaving trees in a development has many ecological benefits such as improving water and air quality, wildlife habitat and reducing erosion. But in an urban environment quality of life benefits are equally important. Leaving trees in a development buffers noise, offers recreational opportunities, reduces energy costs, increases property values, increases a project's marketability, enhances a community's image and facilitates tourism. However, there are costs associated with protecting trees during construction. Some of these costs include time delays. Taking the time to incorporate trees into the building process and protect trees during construction can slow building and add to construction costs. Space provided for trees may directly affect the profitability of the project such as fewer parking spaces or house lots. When trees are damaged by construction, there may be additional costs for removal and replacement.

There are many site design and construction techniques that can be used to protect trees during construction. An urban forester can help recommend methods to protect existing trees and analyze the affect of a "changed" landscape on individual species.

Tree Protection Techniques

The first step in protecting trees is to identify sensitive, unique or particularly valuable trees or areas on the site. Check the local zoning and tree ordinances to see what setbacks are required or what special historic trees or species may exist which require protection by the community. Select trees that have the best chance for survival given the changes that will be made to the site such as grading, paving, utilities, traffic, etc. It is better to select "tree stands or tree islands" rather than protecting individual trees scattered throughout a site.

Identify the critical root zone of the tree (s) related to its species, age, health, location, soil conditions and surrounding vegetation. Organize construction activities such as contractor parking, material storage, temporary field offices, debris bury pits, concrete washouts, etc. away from the trees to be protected. Sign these areas and install protective fencing to minimize disturbance in the critical root zone.

Tree roots are often tangled or fused with roots of other trees that are being cleared on

construction sites. Removing trees adjacent to protection areas can damage the remaining trees by tearing and breaking these fused roots. To reduce this risk, dig a 2-foot deep trench outside the critical root zone to insure a clean cut of roots. The trenches can be back filled with loose soil and mulch to encourage new root development for the protected trees.

Fertilize protected trees before construction begins with a slow-release nitrogen fertilizer to help the trees resist insects and diseases that result from site disturbance. Mulch trees with 4-inch layer of wood chips throughout the critical root zone. Natural debris from clearing vegetation from the site can be used as mulch. Mulching is the single most important thing you can do to protect trees. Fertilize again after construction to help the tree recover its vigor if it has suffered damage. Be careful not to over-fertilize as this can be detrimental.

Prune trees, using proper techniques, to be protected before construction to improve clearance between trees and the proposed structure. Light pruning can improve the tree's vigor. If a tree has been damaged by construction, avoid pruning live plant material as it can accelerate the tree's decline.

Tunneling is an effective technique for installing utility lines that can minimize the impact on critical root systems. Boring equipment can push piping and conduit underneath the roots of trees and even through solid rock. Sometimes several utility lines can be placed in a larger trench rather than having separate lines for each utility.

Local ordinances can prevent pavement installation within the critical root zone of trees. This is the preferred technique. However, the use of porous materials such as interlocking blocks, bricks, hollow brick pavers filled with soil and planted with grass allows the natural exchange of gases, nutrients and water between the soil and the air to nourish the root systems. Site plans can illustrate the construction technique.

The greatest challenge for protecting trees on a construction site is grade change. Usually, the steeper the grade the less overall area of disturbance there will be. Tight grade contours and terracing are techniques used to make slopes steeper and maintain stability. Retaining walls allow for a change in grade without any sloping but can damage remaining trees and change drainage patterns.

Land development and construction have major impacts on the urban forest and it is going to happen in a growing economy and with a growing population. By working with developers, local governments and citizens, urban development can be planned to reduce the negative environmental impact. Our trees can be maintained and replaced to provide adequate tree cover and preserve our quality of life.

Summary

Forests provide us with many products and, at the same time, a place to recreate and find spiritual renewal. It is no wonder that forest management is of concern to many people and that we continually find it the subject of public debate and media attention. With an increasing world population, pressure on our natural resources will become even greater. As we develop natural resource policy, it is imperative that rational discussion, ecological awareness, and scientific principles guide our deliberations

This study guide is merely an introduction to the study of forest ecosystems. The questions for the Georgia Envirothon will be taken from this document. We hope it will adequately prepare you for this competition and encourage you to pursue more natural resource management studies.

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